N-TopAMMA Pre-Processing User's Manual

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Chapter 1

N-TopAMMA Project

The N-TopAMMA project is composed of three modules as shown in the figure below:

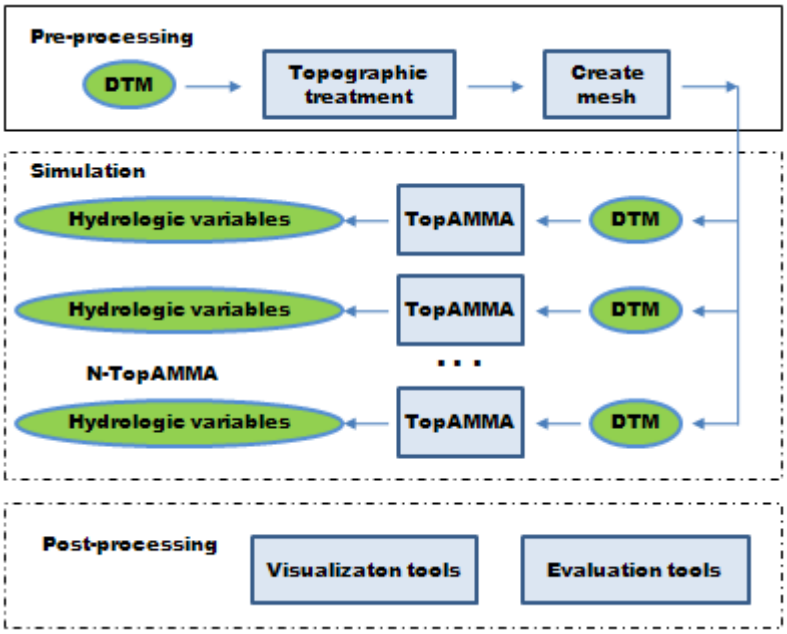

Figure 1.1: N-TopAMMA Architecture

This document provides a User's Manual for the Pre-Processing module.

1.1 Pre-Processing Module

The *Pre-Processing* module is comprised of two steps:

1. Treatment and conditioning of the topographic data (i.e. altitudes), and
2. Creation of an irregular mesh for the TopAMMA model.

1.2 Simulation Module

The *Simulation* module executes the TopAMMA catchment model to route water through each mesh pixel.

1.3 Post-Processing Module

The *Post-Process* module provides visualization graphics using the ASCII output from the TopAMMA model.

Chapter 2

Coordinate Systems

There are three coordinate systems used for the N-TopAMMA model: a **MAP** coordinate system, a **BMP** coordinate system, and a **Geographic** coordinate system. The MAP and BMP coordinate systems are based on the pixels of the model grid, however, their origins and initial pixel numbering are different. The origin of the MAP coordinate system is at the lower-left of the model grid and begins numbering the pixels from (1, 1), while the origin of the BMP coordinate system is at the upper-left of the model grid, and begins numbering the pixels from (0, 0). Each pixel corresponds to a column, row of the model grid. These coordinate systems are shown in the figures below:

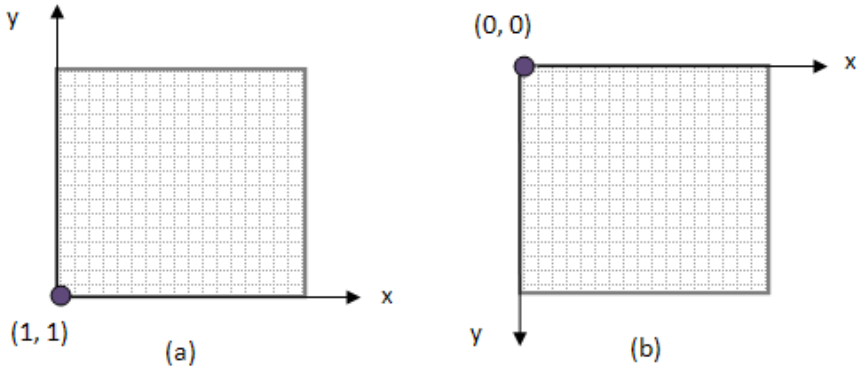

Figure 2.1: (a) MAP coordinates, (b) BMP coordinates

The Geographic coordinates system has it's origin at the lower-left of the model area and is based on either longitude and latitude in decimal degrees, or UTM easting and northing in meters (WGS 84). These coordinate systems with sample values at the origins are shown in the figures below:

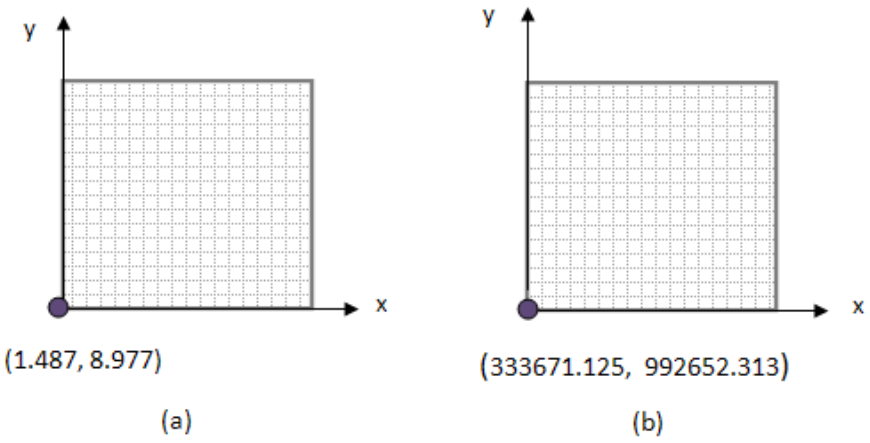

Figure 2.2: (a) Decimal degrees coordinate system, (b) UTM meters coordinate system

Chapter 3

Create Mesh for the Catchment

The topography of a catchment, defined by elevations, is a necessary ingredient for N-TopAMMA. These elevations are furnished by a Digital Terrain Modeling (DTM) raster format file. The ensemble of pre-processing programs is used to extract from the DTM file the necessary information for the TopAMMA model. Presently, the DTM file may have 2,202 pixels in the x-direction (columns) and 2,402 pixels in the y-direction (rows), with up to 400,000 river pixels. These dimensions are specified in the **topography.h** header file and may be changed by recompiling the programs.

It is important to condition the raw DTM file of the catchment area so that pixels outside of the catchment are designated as such. This is done by *extracting* the overall catchment based on the outlet of the catchment. To help clarify what conditioning the raw DTM file means, we can first look at the elevations in a raw DTM file of the Ohhvo Catchment as shown in the following figure:

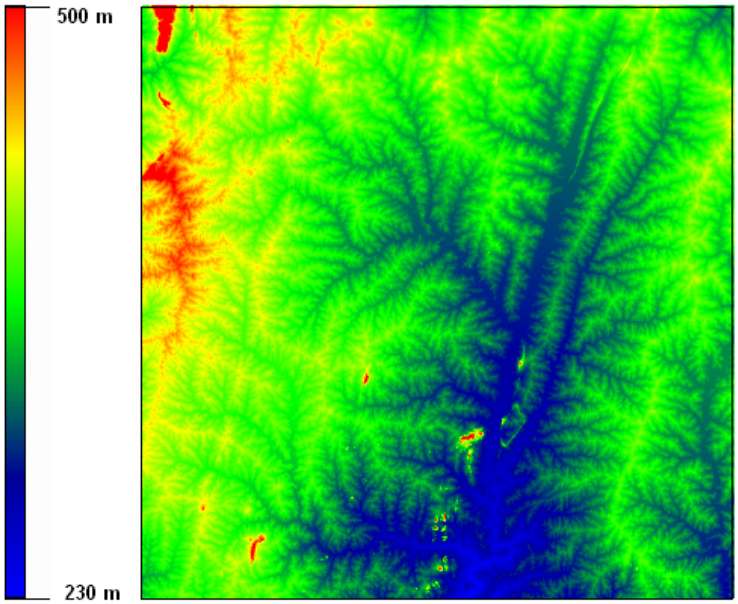

Figure 3.1: Raw Catchment Elevations

From this figure it is not clear where the boundaries of the Ohhvo catchment are, and in fact some of the pixels are outside of this catchment. However, since these pixels are included in the data file, they will be considered by the TopAMMA model programs which can lead to problems with the results of these programs. Therefore, to make sure none of the pixels not physically part of the main catchment are considered during processing, we can *Extract* the main catchment from the raw data, resulting in an elevation map as shown in the following figure:

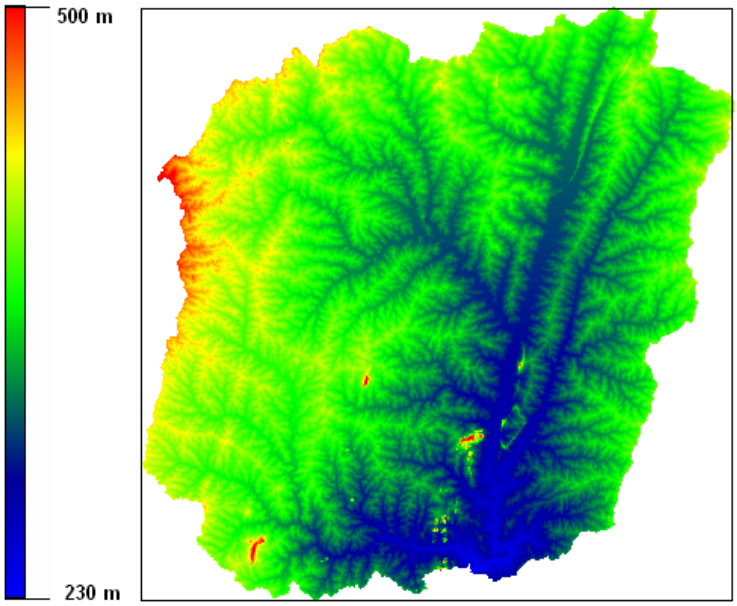

Figure 3.2: Conditioned Catchment Elevations

This figure shows the boundaries of the catchment clearly delineated and now only the pixels that are part of the main catchment are included in the data file.

The following sections provide the sequence in which the pre-processing programs must be executed to first condition (i.e. extract) and treat the catchment, and then create the mesh files for this catchment.

3.1 FillSink Program for the Raw Catchment

This program checks if any sinks exist in the .DTM file. Based on the raw .DTM file, the drainage pathways of water in the catchment will be calculated. This requires that there are no *sinks* (topographic depressions, zones of high or low points) so that the subsequent algorithms are able to calculate drainage that is not blocked. Therefore, the first step consists of running FillSink to correct the raw .DTM to fill in any holes.

3.1.1 User Entries

The following items are entered by the user:

- **BASENAME of the catchment:**

  The basename of the catchment is used to identify the raw .DTM file that the FillSink program will process. The extension of the file must be .DTM and the basename must be entered without an extension. A relative or full path may be included with the basename.

- **Mesh size units type :**

  The mesh size units type indicates whether the raw DTM file x, y-dimensions are based on decimal degrees or UTM meters (WGS84). Enter 'm' for UTM meters or 'd' for decimal degrees.

3.1.2 Input File

The file read by this program is shown in the following figure:

Figure 3.3: File read by FillSink program for the raw catchment

- **BASENAME.dtm** is the raw DTM file for the catchment.

The ASCII format of the raw DTM file and all of the subsequent **.map** files is the same:

- 5 lines for comments
- X-coordinate of bottom-left pixel (UTM meters or decimal degrees)
- Y-coordinate of bottom-left pixel (UTM meters or decimal degrees)
- Number of abscissa (columns)
- Number of ordinates (rows)
- Outside value
- Mesh size (UTM meters or decimal degrees)
- Minimum value in the map
- Maximum value in the map
- Map Data: One value per line of the file, in the order row by row starting at the bottom row, from left to right (i.e. starting at the bottom row of the grid (row 1), all x-values for that row are in the file first; followed by all x-values for row 2, etc.)

A sample of the top of the **BASENAME.dtm** file with mesh size and origin coordinates in decimal degrees is given below:

```
                1.486667 Abscissa bottom-left pixel
                8.976667 Ordinate bottom-left pixel
                    1582 Number of Abscissa
                    1459 Number of Ordinates
                  -1.000 Outside value
               0.0008333 Mesh size (d)
                 223.000 Minimal value
                 644.000 Maximal value
355.
357.
358.
360.
360.
361.
```

```
361.
361.
...
```

A sample of the top of a **BASENAME.dtm** file with mesh size and origin coordinates in UTM meters (WGS84) is given below:

```
          333671.13516 Abscissa bottom-left pixel
          992652.26080 Ordinate bottom-left pixel
                  1582 Number of Abscissa
                  1459 Number of Ordinates
                -1.000 Outside value
                91.800 Mesh size (m)
               223.000 Minimal value
               644.000 Maximal value
355.
357.
358.
360.
360.
361.
361.
361.
...
```

A graphical view of the **BASENAME.dtm** file for the raw catchment is shown in the following figure:

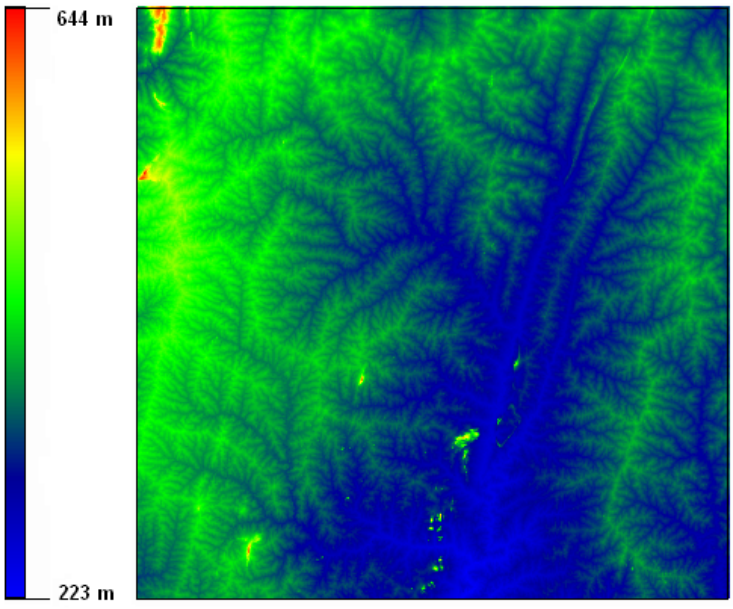

Figure 3.4: Raw DTM map for the catchment

3.1.3 Output Files

The files written by this program are shown in the following figure:

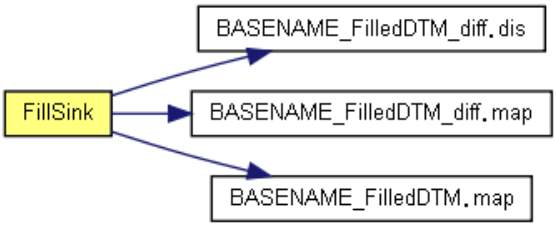

Figure 3.5: Files written by FillSink program for the raw catchment

- **BASENAME_FilledDTM.map** is the 'filled' DTM file for the catchment.
- **BASENAME_FilledDTM_diff.map** is a map of the differences between the initial DTM file and the 'filled' file.
- **BASENAME_FilledDTM_diff.dis** is the distribution of the 'filled' altitudes.

A graphical view of the **BASENAME_FilledDTM.map** for the raw catchment is shown in the following figure:

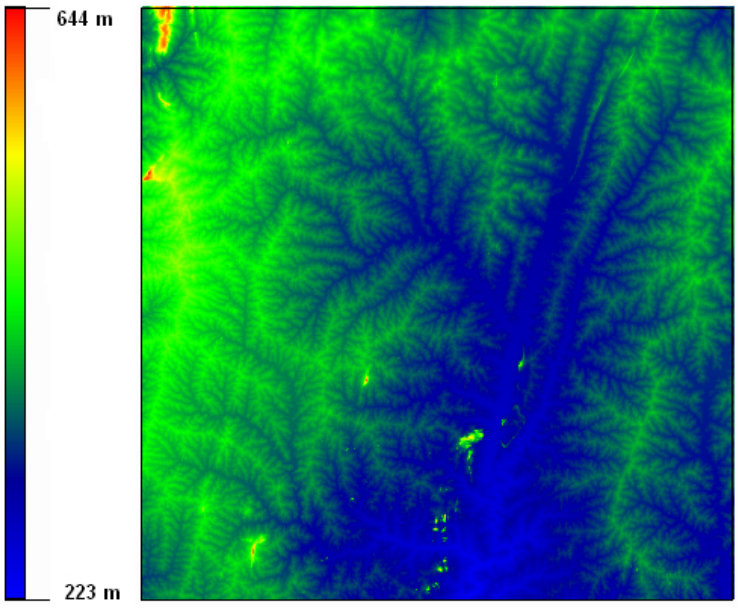

Figure 3.6: Filled DTM map for the raw catchment

A graphical view of the **BASENAME_FilledDTM_diff.map** for the raw catchment is shown in the following figure:

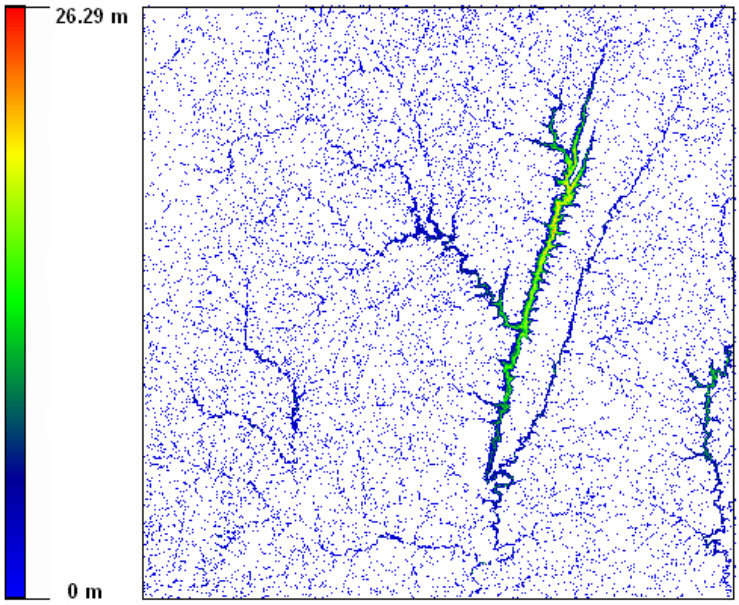

Figure 3.7: Filled difference map for the raw catchment

The **BASENAME_FilledDTM_diff.dis** file consists of 3 columns of ASCII data for each distribution step:

- Beginning of step
- End of step
- Difference value for step

For example, several lines from the beginning and end of this file are shown below:

```
[  -0.013:    0.013[  2054889.
[   0.013:    0.039[        0.
[   0.039:    0.066[     1010.
[   0.066:    0.092[        0.
[   0.092:    0.118[    67155.
[   0.118:    0.145[        0.
[   0.145:    0.171[     9404.
[   0.171:    0.197[        0.
...
[  26.096:   26.122[        0.
[  26.122:   26.149[        1.
[  26.149:   26.175[        0.
[  26.175:   26.201[        0.
[  26.201:   26.228[        0.
[  26.228:   26.254[        0.
[  26.254:   26.280[        0.
[  26.280:   26.307[        1.
```

3.2 Connections Program for the Raw Catchment

This program sorts the DTM pixels by decreasing elevation and writes files for both monodimensional and multidimensional-connections.

3.2.1 User Entries

The following item is entered by the user:

- **BASENAME of the catchment**
  The basename will match the BASENAME entered for the **FillSink** program.

3.2.2 Input File

The file read by this program is shown in the following figure:

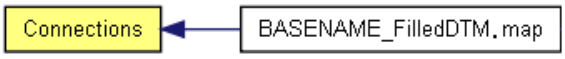

Figure 3.8: File read by Connections program for the raw catchment

- **BASENAME_FilledDTM.map** is the 'filled' DTM file for the catchment created by the **FillSink** program.

3.2.3 Output Files

The files written by this program are shown in the following figure:

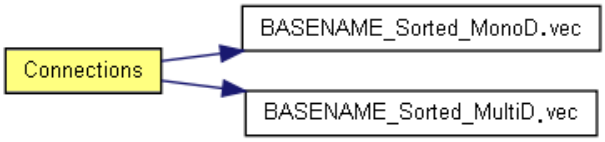

Figure 3.9: Files written by Connections program for the raw catchment

- **BASENAME_Sorted_MonoD.vec** has the monodimensional algorithm-connections.
- **BASENAME_Sorted_MultiD.vec** has the multidimensional algorithm-connections.

The **BASENAME_Sorted_MonoD.vec** file consists of ASCII data in the following format:

- Line of text with heading information for the columns
- Number of pixels defining the catchment
- Minimum elevation (m)
- Maximum elevation (m)
- Number of abscissa (columns)

- Number of ordinates (rows)
- Mesh size (meters or degrees), [average mesh size in meters if the mesh size is in degrees]
- Four columns of data for each pixel, followed by variable number of columns:
  - Pixel reference number
  - Elevation in meters
  - Type of pixel (at this time the type of pixel is not known and set to zero)
  - Number of pixels that are upslope, then for each upslope pixel, two columns:
    * the upslope pixel reference number, and
    * percent contribution to this pixel (always 1 for monodimensional-connections)

An example of the header for this file and several lines of data follows:

```
 Pixel_Ref Z_(m) Pixel_Type Nb_Upslopes_Pixels (UpPixel_Ref,UpPixel_%Giving)
                  2308136 Number of pixels defining the catchment
                   228.00 Minimal elevation (m)
                   644.00 Maximal elevation (m)
                     1582 Number of Abscissa
                     1459 Number of Ordinates
                0.0008333 Space Resolution (degrees)   (   91.80 meters)
 ...
   177480  613.000 0 0
  1637385  613.000 0 2 1635802. 1.000000 1635803. 1.000000
  1638964  613.000 0 0
  1662704  613.000 0 0
  2306619  613.000 0 0
  2306621  613.000 0 0
  2298716  613.000 0 0
  1651627  612.000 0 2 1653208. 1.000000 1653209. 1.000000
  1631053  612.000 0 1 1632635. 1.000000
  1650044  612.000 0 0
   175898  612.000 0 0
  1637386  612.000 0 0
  1635805  612.000 0 0
  2303463  612.000 0 3 2301880. 1.000000 2303462. 1.000000 2305044. 1.000000
 ...
```

The **BASENAME_Sorted_MultiD.vec** file has the same format as the **BASENAME_Sorted_-MonoD.vec**, however it has more upslope connections with variable percent contributions to the pixel, as shown in the following sample of lines from that file:

```
Pixel_Ref Z_(m) Pixel_Type Nb_Upslopes_Pixels (UpPixel_Ref,UpPixel_%Giving)
                  2308136 Number of pixels defining the catchment
                   228.00 Minimal elevation (m)
                   644.00 Maximal elevation (m)
                     1582 Number of Abscissa
                     1459 Number of Ordinates
                0.0008333 Space Resolution (degrees)   (   91.80 meters)
  1654791  644.000 0 0
  1654790  642.000 0 1 1654791. 0.030303
  1654792  634.000 0 1 1654791. 0.151515
  1653209  633.000 0 3 1654791. 0.166667 1654790. 0.057325 1654792. 0.009009
  1632632  633.000 0 0
  1656373  633.000 0 3 1654791. 0.166667 1654790. 0.057325 1654792. 0.009009
  1653208  632.000 0 3 1654790. 0.127389 1654791. 0.090909 1653209. 0.021053
  1634219  631.000 0 0
  1656372  631.000 0 3 1654790. 0.140127 1654791. 0.098485 1656373. 0.074074
  1659538  631.000 0 0
  1632637  630.000 0 1 1634219. 0.041667
```

```
  1657955  630.000 0 3 1656373. 0.111111 1656372. 0.010204 1659538. 0.007353
  1632636  629.000 0 2 1632637. 0.017094 1634219. 0.041667
  1634220  628.000 0 2 1634219. 0.125000 1632637. 0.017094
  1634218  628.000 0 3 1632636. 0.021053 1634219. 0.125000 1632637. 0.017094
  1632633  627.000 0 1 1632632. 0.089552
  1632635  627.000 0 2 1632636. 0.042105 1634218. 0.040000
...
```

3.3 Index_MonoD Program for the Raw Catchment

Using the connections generated by program **Connections**, this program is able to calculate the mono-directional hydrographic network and the topographic indexes as the logarithm of the ratio of the drainage area of a pixel to the slope of the local topography.

3.3.1 User Entries

The following items are entered by the user:

- **BASENAME of the catchment**
- **Drainage area threshold (m^2)**
- **Topographic index threshold**

3.3.2 Input Files

The files read by this program are shown in the following figure:

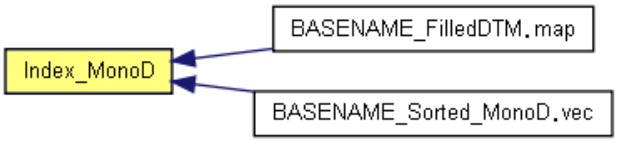

Figure 3.10: Files read by Index_MonoD program for the raw catchment

- **BASENAME_FilledDTM.map** is the 'filled' DTM file for the catchment created by the /b FillSink program.
- **BASENAME_Sorted_MonoD.vec** is the monodimensional algorithm-connections file created by the /b Connections program.

3.3.3 Output Files

The files written by this program are shown in the following figure:

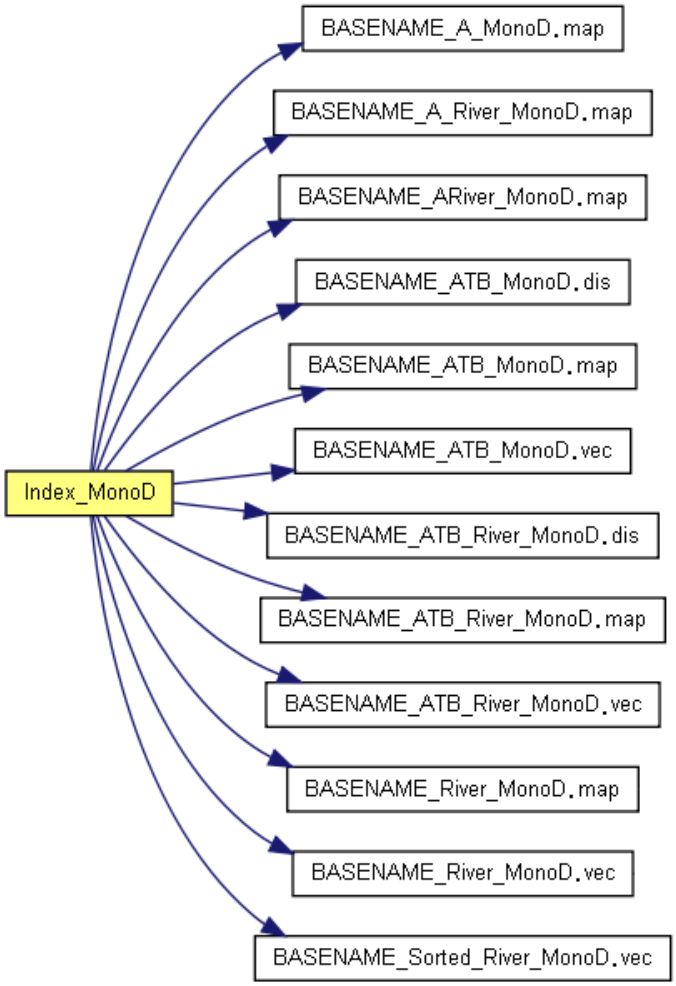

Figure 3.11: Files written by Index_MonoD program for the raw catchment

- **BASENAME_A_MonoD.map** is a map of the drainage areas not taking the rivers into account.
- **BASENAME_A_River_MonoD.map** is a map of drainage areas taking the rivers into account.
- **BASENAME_ARiver_MonoD.map** is a map of the drainage areas for the river pixels.
- **BASENAME_ATB_MonoD.dis** has the statistical distribution of the topographic indexes calculated not taking the river into account.
- **BASENAME_ATB_MonoD.map** is a map of the topographic indexes calculated not taking the river into account.
- **BASENAME_ATB_MonoD.vec** is a map of the topographic indexes calculated not taking the river into account and reorganized according to the connections between pixels.
- **BASENAME_ATB_River_MonoD.dis** has the statistical distribution of the topographic indexes calculated taking the river into account.
- **BASENAME_ATB_River_MonoD.map** is a map of the topographic indexes calculated taking the river into account.

- **BASENAME_ATB_River_MonoD.vec** is a map of topographic indexes calculated taking the river into account and reorganizing according to the connections between pixels.
- **BASENAME_River_MonoD.map** is a map of the river pixels.
- **BASENAME_River_MonoD.vec** has the river vectors.
- **BASENAME_Sorted_River_MonoD.vec** has the vectors of the river pixels reorganized according to the connections.

A graphical view of the **BASENAME_A_MonoD.map** file shows the pixels with drainage areas between 8 and 14,000 km^2 (not taking the rivers into account):

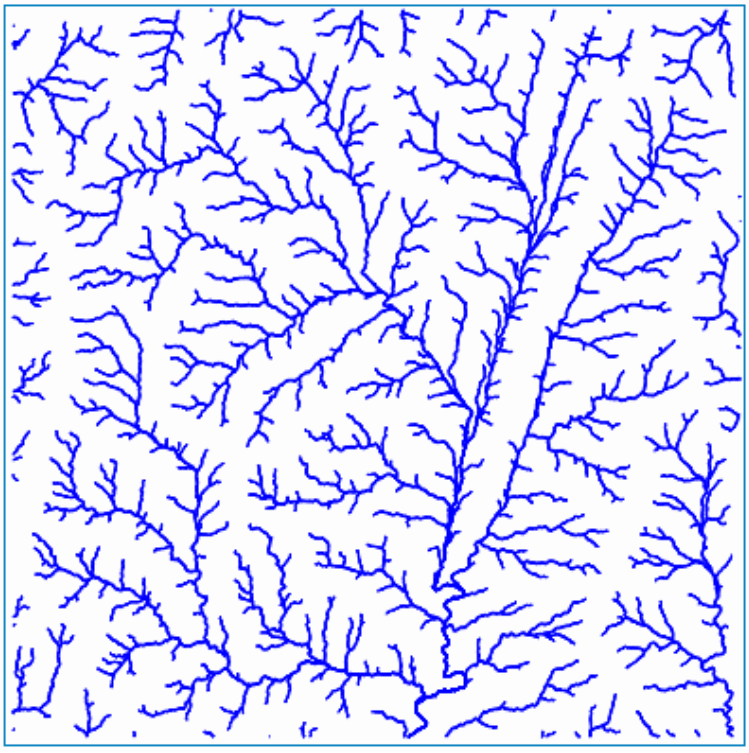

Figure 3.12: Drainage areas (not accounting for rivers) 8 to 14,000 km2

3.4 Mask2 Program for the Conditioned Catchment

Given outlet coordinates, this program creates a mask file for the conditioned catchment from a DTM file of the raw catchment. The mask file contains the values (1) for pixels located in the catchment, and (0) for pixels located outside the catchment. The contour for the conditioned catchment is calculated by going back up from the outlet to the crest by the steepest slope, and then following the crest.

If the Geographic coordinate system is selected for input, then the approximate drainage area for the outlet is also required. The program uses this area to find the nearest river pixel to the entered coordinates that has a drainage area within 5% of the specified drainage area. Zero may be entered for the drainage area, however, the nearest river pixel found is not guaranteed to be in the correct basin for the outlet.

3.4.1 User Entries

The following items are entered by the user:

- BASENAME of the catchment
- MASKNAME, mask name for the catchment (extension **.mask** will be added to create the mask file)
- Coordinate system (1 = MAP file, 2 = BMP, 3 = Geographic)
  - For the MAP and BMP coordinate systems:
    Enter X,Y-coordinates of the outlet
  - For the Geographic coordinate system:
    Enter X,Y-coordinates of the outlet, and approximate drainage area (km^2)

3.4.2 Input Files

The files read by this program are shown in the following figure:

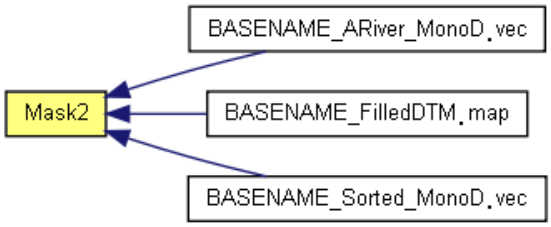

Figure 3.13: Files read by Mask2 program for the conditioned catchment

3.4.3 Output File

The file written by this program is shown in the following figure:

Figure 3.14: File written by Mask2 program for the conditioned catchment

3.5 Extract Program for the Conditioned Catchment

Given a DTM file and a catchment *mask* file, this program extracts a *conditioned* DTM file for the catchment.

3.5.1 User Entries

The following items are entered by the user:

- BASENAME of the catchment
- MASKNAME for the catchment
- SUBBASENAME, subbasename for the conditioned catchment

3.5.2 Input Files

The files read by this program are shown in the following figure:

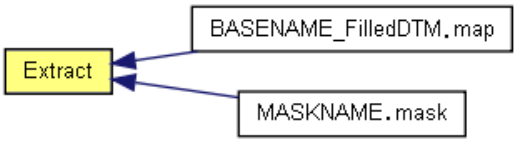

Figure 3.15: Files read by Extract program for the conditioned catchment

3.5.3 Output Files

The files written by this program are shown in the following figure:

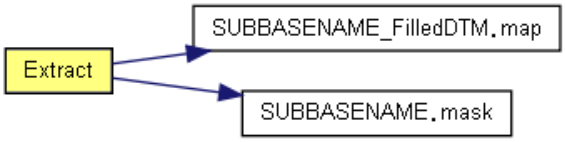

Figure 3.16: Files written by Extract program for the conditioned catchment

3.6 Connections Program for the Conditioned Catchment

This program sorts the conditioned DTM pixels by decreasing elevation.

3.6.1 User Entries

The following item is entered by the user:

- SUBBASENAME of the catchment:
  The subbasename will be the subbasename entered for the **Extract** program.

3.6.2 Input File

The file read by this program is shown in the following figure:

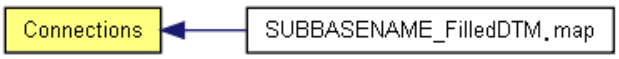

Figure 3.17: File read by Connections program for the conditioned catchment

3.6.3 Output Files

The files written by this program are shown in the following figure:

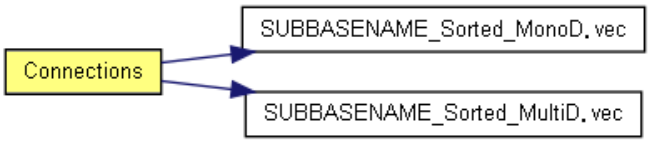

Figure 3.18: Files written by Connections program for the conditioned catchment

3.7 Index_MonoD Program for the Conditioned Catchment

This program calculates the mono-directional hydrographic network and topographic indexes for the conditioned catchment.

3.7.1 User Entries

The following items are entered by the user:

- SUBBASENAME of the catchment
- Drainage area threshold (m^2)
- Topographic index threshold

3.7.2 Input Files

The files read by this program are shown in the following figure:

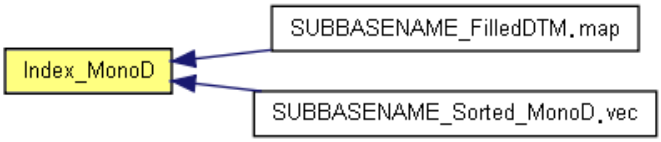

Figure 3.19: Files read by Index_MonoD program for the conditioned catchment

3.7.3 Output Files

The files written by this program are shown in the following figure:

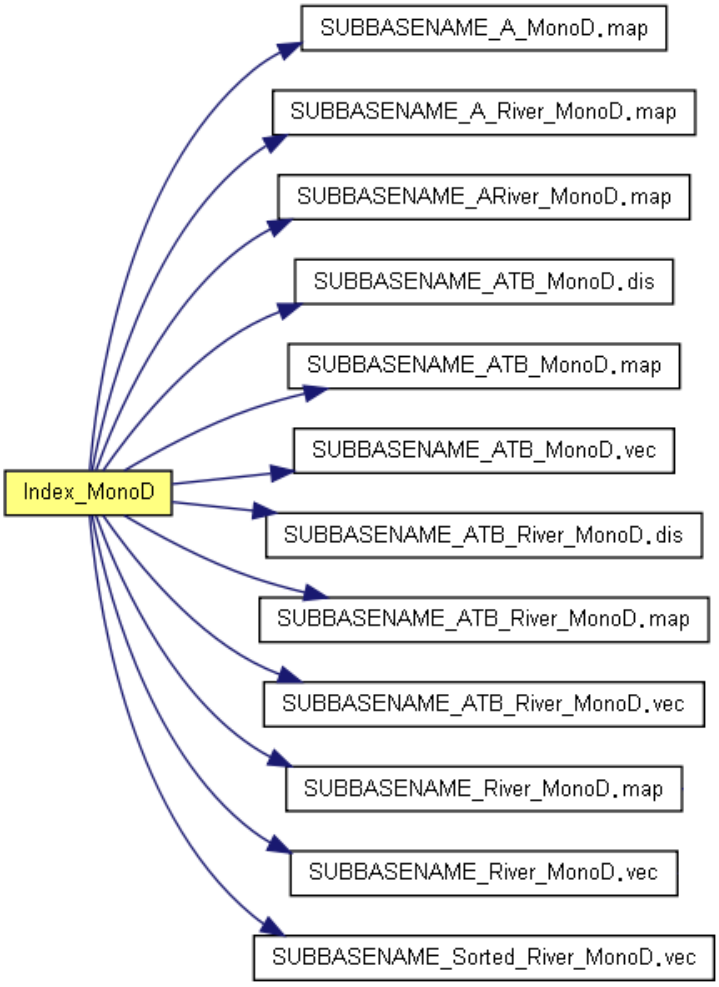

Figure 3.20: Files written by Index_MonoD program for the conditioned catchment

3.8 Index_MultiD Program for the Conditioned Catchment

Using the connections generated by programs **Connections** and **Index_MonoD**, this program is able to calculate the multi-directional hydrographic network and the topographic indexes as the logarithm of the ratio of the drainage area of a pixel to the slope of the local topography.

3.8.1 User Entries

The following item is entered by the user:

- SUBBASENAME of the catchment

3.8.2 Input Files

The files read by this program are shown in the following figure:

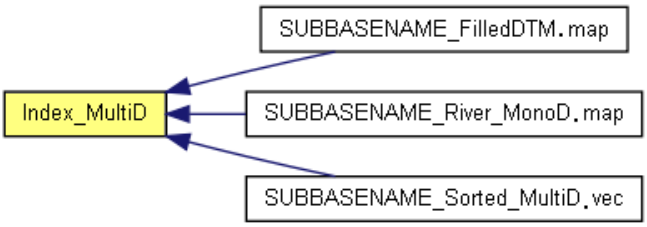

Figure 3.21: Files read by Index_MultiD program for the conditioned catchment

3.8.3 Output Files

The files written by this program are shown in the following figure:

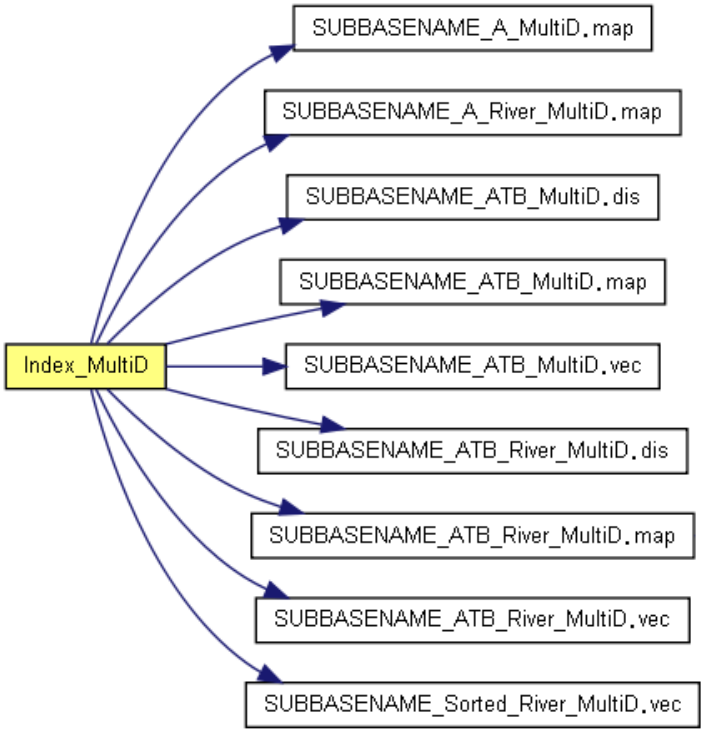

Figure 3.22: Files written by Index_MultiD program for the conditioned catchment

3.9 Outlet_Coordinates Program for the Conditioned Catchment

This program finds the nearest river pixel for specified outlet coordinates, and writes the **Outlets.list** file required by the **Define_Mesh** program. This program will search 50 pixels in each direction from the specified pixel to find the nearest river pixel. If a drainage area is also specified for the outlet, then the nearest river pixel with a drainage area within 5 percent of the specified area is found. If the drainage area is not specified, then the nearest river pixel will be found, but it may not be correct as an outlet pixel.

The outlet coordinates may be entered as a single point or a list of points in the file **Coordinates.list**, which should be placed in the same directory as the data files. The coordinates may be in either meters (UTM) or decimal degrees.

3.9.1 User Entries

The following items are entered by the user:

- SUBBASENAME of the catchment
- Option to read coordinates from file **Coordinates.list** ('y' = yes, 'n' = no)
- If not reading from the **Coordinates.list** file, enter:

  x-coordinate, y-coordinate, and drainage area (km^2)

- Specify whether to write results to screen (0) or file (1)
- If writing results to a file, enter 'UserFilename.ext'

3.9.2 Input Files

The files read by this program are shown in the following figure:

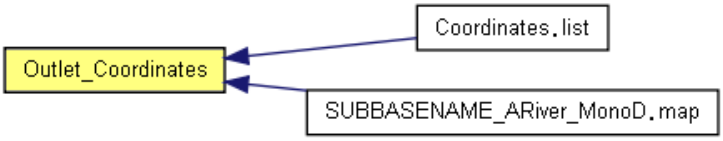

Figure 3.23: Files read by Outlet_Coordinates program for the conditioned catchment

The format of **Coordinates.list** consists of 3 required columns of data for each outlet. Additional information may be included in the file, but any information after the third column is ignored. These columns are:

- x-coordinate in decimal degrees or meters
- y-coordinate in decimal degrees or meters
- drainage area in km^2 (enter 0 for drainage area if it is not known)
- [catchment number]: Optional number assigned to this outlet
- [catchment name]: Optional name for this outlet

Sample input for the **Coordinates.list** file for the Ohhvo catchment:

```
2.02203728    9.12705902      402       1      Aguimo
2.39930824    9.75489921     1607       2      Bori
1.60990827    9.75223248       12.8     3      Ara
1.9208887     9.7802079        17.4     4      Bokperou
2.09544       9.72786609     1330       5      Donga Afon
1.94471126    9.71056822      586       6      Donga
1.77431718    9.76364218      292       7      Koua
1.83527397    9.80879942      409       8      Nekete
1.68654088    9.75201188      105       9      Kolo
2.15400499    9.72264406     3283      10      Aval Sani
2.26752331    9.1992043     10050      11      Beterou
2.09516752    9.75118892     1165      12      Afon
1.86427304    9.95599953      515      13      Tebou
2.12187515    9.75616043      745      14      Sani
2.09227804    9.08837034     3133      15      Cote 238
1.88124791    9.08246687     2334      16      Igbomakoro
1.81920115    9.23016361     1378      17      Sarmanga
2.11599815    9.38473535      293      18      Wewe
2.37596054    9.35897022     2162      19      Barerou
```

3.9.3 Output Files

The files written by this program are shown in the following figure:

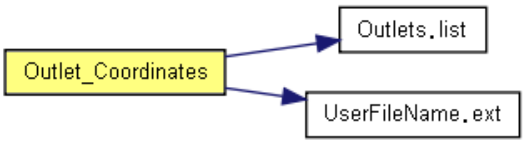

Figure 3.24: Files written by Outlet_Coordinates program for the conditioned catchment

Outlets.list will be written to the same directory that the data files are in, and the user specified filename will be written to the executable directory unless a path is specified with the file name.

The format of **Outlets.list** consists of one line with the number of entries and then two columns for each entry that include:

- x-pixel coordinate
- y-pixel coordinate

Sample output for the **Outlets.list** file for the conditioned Ohhvo catchment:

```
  19
 643         180
1106         934
 149         929
 517         955
 734         897
 550         880
 345         943
 418         998
 240         929
 804         893
 940         267
 731         929
 453        1174
 762         935
 725         131
 474         127
 399         304
 756         489
1068         459
```

Additional information related to the outlets is output from this program. Sample output for the **UserFileName.ext** file for the Ohhvo catchment is given below:

```
   Initial     Initial     Initial      Initial       Final       Final
 X degrees   Y degrees     X value      Y value     X value     Y value
 2.0220373   9.1270590   392541.00   1009045.16   392534.53   1009037.99  ...
 2.3993082   9.7548990   434116.99   1078372.11   435048.09   1078415.05
 1.6099082   9.7522326   347523.99   1078332.24   347569.59   1078210.75
 1.9208887   9.7802076   381648.99   1081301.16   381217.94   1080483.56
 2.0954399   9.7278662   400778.99   1075457.17   401037.86   1075080.96
 1.9447112   9.7105684   384237.99   1073592.21   384212.72   1073563.04
 1.7743171   9.7636423   365565.00   1079524.22   365492.04   1079431.55
```

```
  1.8352740   9.8087997  372269.00  1084494.24  372182.52  1084476.14
  1.6865408   9.7520123  355930.99  1078274.26  355888.70  1078177.49
  2.1540051   9.7226439  407202.01  1074863.13  407435.78  1074695.92
  2.2675233   9.1992044  419533.00  1016958.15  419746.79  1016989.41
  2.0951676   9.7511892  400756.01  1078036.20  400771.50  1078030.24
  1.8642731   9.9559994  375505.00  1100761.18  375436.60  1100683.43
  2.1218750   9.7561607  403686.99  1078578.20  403606.50  1078575.61
  2.0922780   9.0883703  400248.99  1004747.15  400032.01  1004503.55
  1.8812479   9.0824671  377053.99  1004159.20  377043.46  1004199.27
  1.8192011   9.2301636  370287.99  1020513.19  370227.88  1020531.04
  2.1159983   9.3847351  402937.01  1037510.13  402952.67  1037482.29
  2.3759606   9.3589706  431477.00  1034600.18  431495.83  1034656.98

  Init Col.  Init Line  Col.  Line BMP I BMP J Init Area      Area
...     643        180   643   180   642  1278    402.00    391.03
       1096        934  1106   934  1105   524   1607.00   1600.18
        148        930   149   929   148   529     12.80     12.60
        522        964   517   955   516   503     17.40     16.78
        731        901   734   897   733   561   1330.00   1290.68
        550        880   550   880   549   578    586.00    584.44
        346        944   345   943   344   515    292.00    285.19
        419        998   418   998   417   460    409.00    401.09
        240        930   240   929   239   529    105.00    100.91
        801        895   804   893   803   565   3283.00   3280.21
        938        267   940   267   939  1191  10050.00  10084.97
        731        929   731   929   730   529   1165.00   1180.49
        454       1175   453  1174   452   284    515.00    531.57
        763        935   762   935   761   523    745.00    745.00
        727        134   725   131   724  1327   3133.00   3051.15
        474        127   474   127   473  1331   2334.00   2317.18
        400        304   399   304   398  1154   1378.00   1358.47
        756        489   756   489   755   969    293.00    295.32
       1068        458  1068   459  1067   999   2162.00   2135.69
```

The columns in the screen output or **UserFileName.ext** file are described below:

- *Initial X degrees* is the input x-coordinate for the outlet in decimal degrees.
- *Initial Y degrees* is the input y-coordinate for the outlet in decimal degrees.
- *Initial X value* is the UTM easting meters value corresponding to the *Initial X degrees* input.
- *Initial Y value* is the UTM northing meters value corresponding to the *Initial Y degrees* input.
- *Final X value* is the UTM easting meters value for the nearest river pixel to the input coordinates.
- *Final Y value* is the UTM northing meters value for the nearest river pixel to the input coordinates.
- *Init Col.* is the pixel column corresponding to the *Initial X degrees* input. The pixel column coordinates start with index one at the left of the grid, and increase to the right.
- *Init Line* is the pixel line, or row, corresponding to the *Initial Y degrees* input. The pixel line/row coordinates start with index one at the bottom of the grid, and increase going up.
- *Col.* is the pixel column for the nearest river pixel to the input coordinates.
- *Line* is the pixel line, or row, for the nearest river pixel to the input coordinates.
- *BMP I* is the BMP column for the nearest river pixel to the input coordinates. The BMP I coordinates start with index zero at the left of the grid, and increase to the right.
- *BMP J* is the BMP line, or row, for the nearest river pixel to the input coordinates. The BMP J coordinates start with index zero at the top of the grid, and increase going down.
- *Init Area* is the input drainage area in km^2 .
- *Area* is the drainage area in km^2 corresponding to the final outlet pixel coordinates.

3.10 Distances Program for the Conditioned Catchment

This program calculates distances for each pixel in the catchment. The two distances calculated for each pixel are:

1. the distance that water flows from that pixel to the river, and
2. the distance from that point at the river to the outlet.

Note: If an error occurs when running this program using the raw catchment data files, this indicates a conditioned catchment must be created, as described above.

3.10.1 User Entries

The following item is entered by the user:

- SUBBASENAME of the catchment

3.10.2 Input Files

The files read by this program are shown in the following figure:

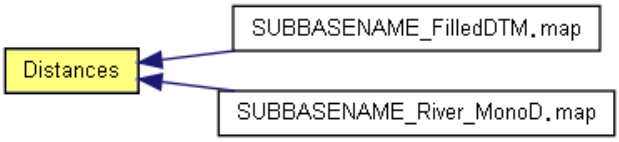

Figure 3.25: Files read by Distances program for the conditioned catchment

3.10.3 Output Files

The files written by this program are shown in the following figure:

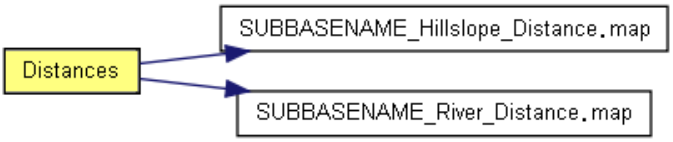

Figure 3.26: Files written by Distances program for the conditioned catchment

3.11 Geomorpho Program for the Conditioned Catchment

This program determines the geomorphic characteristics of the catchment, and the transfer functions and paths for water to travel to the outlet, including both surface runoff and subsurface flow.

3.11.1 User Entries

The following items are entered by the user:

- SUBBASENAME of the catchment
- Velocity for river (m/s)
- Velocity for hillslope (m/s)
- Ac Threshold ($0 < x < 1$)
- Time step (sec)

3.11.2 Input Files

The files read by this program are shown in the following figure:

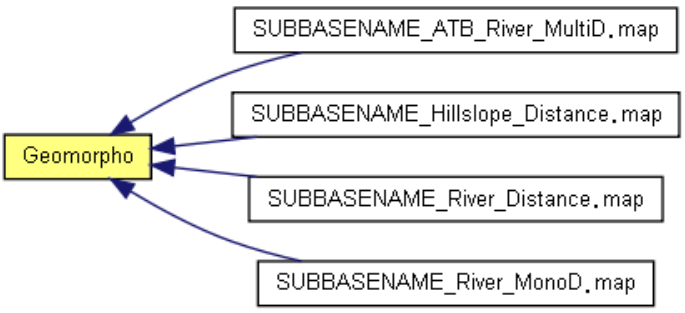

Figure 3.27: Files read by Geomorpho program for the conditioned catchment

3.11.3 Output Files

The files written by this program are shown in the following figure:

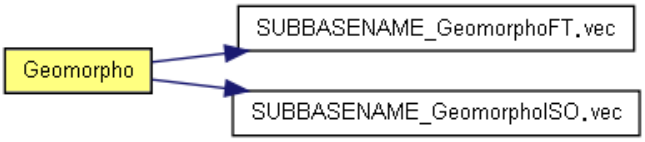

Figure 3.28: Files written by Geomorpho program for the conditioned catchment

3.12 Input_Mesh for the Conditioned Catchment

This program creates a data file for use by the **Define_Mesh** program to calculate the hydrologic mesh.

3.12.1 User Entries

The following item is entered by the user:

- SUBBASENAME of the catchment

3.12.2 Input Files

The files read by this program are shown in the following figure:

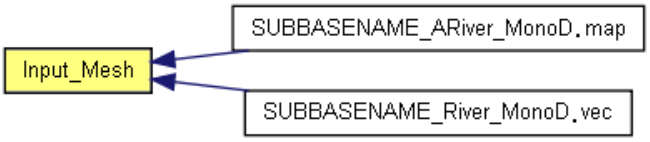

Figure 3.29: Files read by Input_Mesh program for the conditioned catchment

3.12.3 Output File

The file written by this program is shown in the following figure:

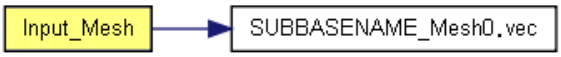

Figure 3.30: File written by Input_Mesh program for the conditioned catchment

3.13 Define_Mesh for the Conditioned Catchment

This program realizes the hydrologic mesh for a region. It does this by defining the coordinates of the outlets of the effective mesh from the fixed outlets specified in **Outlets.list**. A list of the meshes defined by this program is displayed and should be reviewed by the user to verify that the drainage areas for the meshes are reasonable. It's possible for the drainage area of the last mesh to be somewhat smaller than the other meshes, and it's up to the user to decide if this is acceptable. If it is not, rerun the program and change the nominal area of the meshes.

Note: If an error message occurs stating that an outlet is not a river pixel, check that the correct **Outlets.list** file was created by the **Outlet_Coordinates** program.

3.13.1 User Entries

The following items are entered by the user:

- SUBBASENAME of the catchment
- Detect position of Fixed Outlets ('y' or 'n'). If 'y' is selected, then the **Outlets.list** file will be read, and **Outlets.list.updated** file will be written.

3.13.2 Input Files

The files read by this program are shown in the following figure:

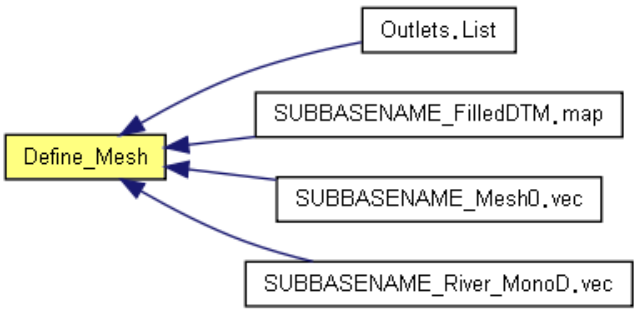

Figure 3.31: Files read by Define_Mesh program for the conditioned catchment

3.13.3 Output Files

The files written by this program are shown in the following figure:

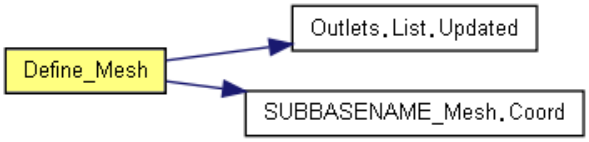

Figure 3.32: Files written by Define_Mesh program for the conditioned catchment

The approximate locations of the outlets as given in the **Outlets.list.updated** file are shown in the following figure:

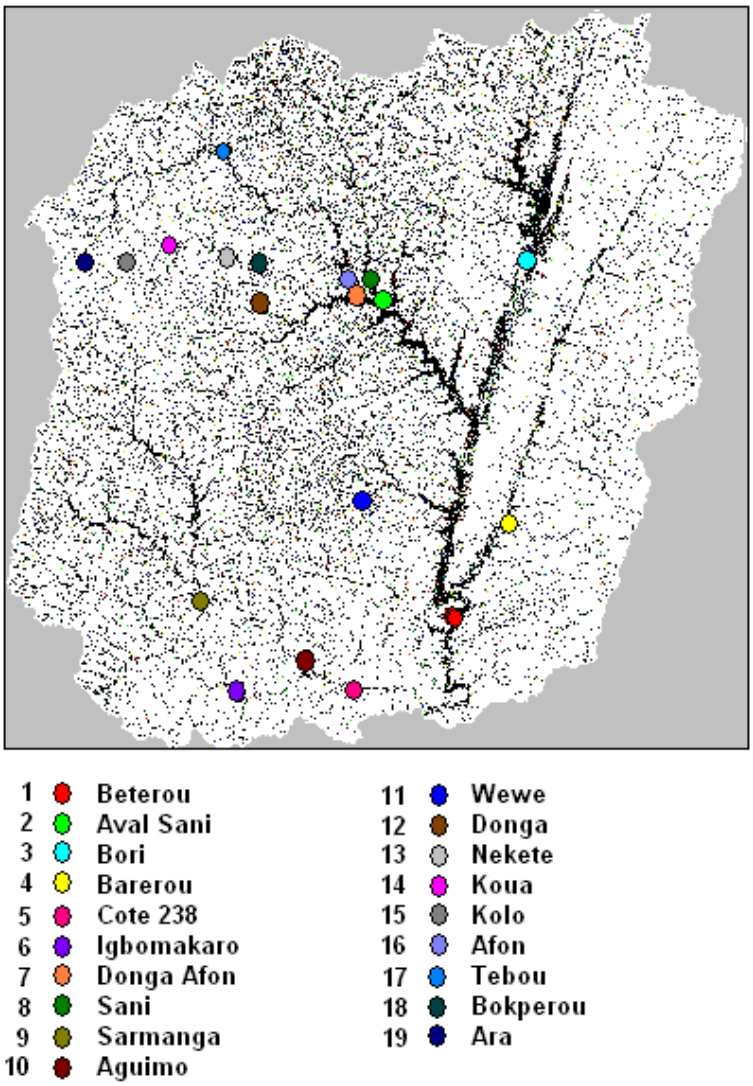

Figure 3.33: Outlet locations for the conditioned catchment

3.14 Draw_Mesh for the Conditioned Catchment

This program creates the mesh files for the catchment.

3.14.1 User Entries

The following items are entered by the user:

- SUBBASENAME of the catchment
- Detect position of Fixed Outlets ('y' or 'n'). If 'y' is selected, then the **Outlets.list.updated** file will be read.

3.14.2 Input Files

The files read by this program are shown in the following figure:

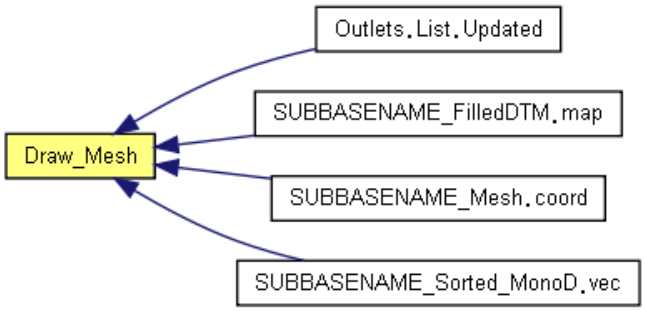

Figure 3.34: Files read by Draw_Mesh program for the conditioned catchment

3.14.3 Output Files

The files written by this program are shown in the following figure, with one **SUBBASENAME_OutletN** file written for each of *N* outlets.

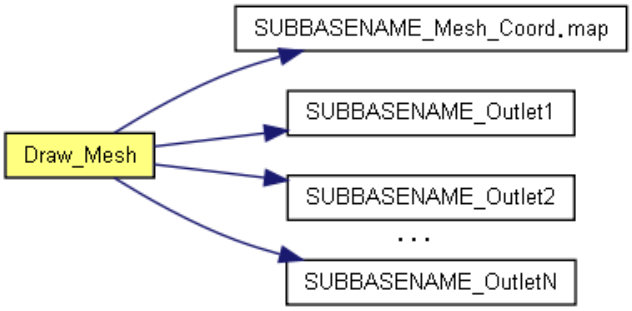

Figure 3.35: Files written by Draw_Mesh program for the conditioned catchment

The meshes created by the Draw_Mesh program in the **SUBBASENAME_Mesh_Coord.map** file are shown in the following figure:

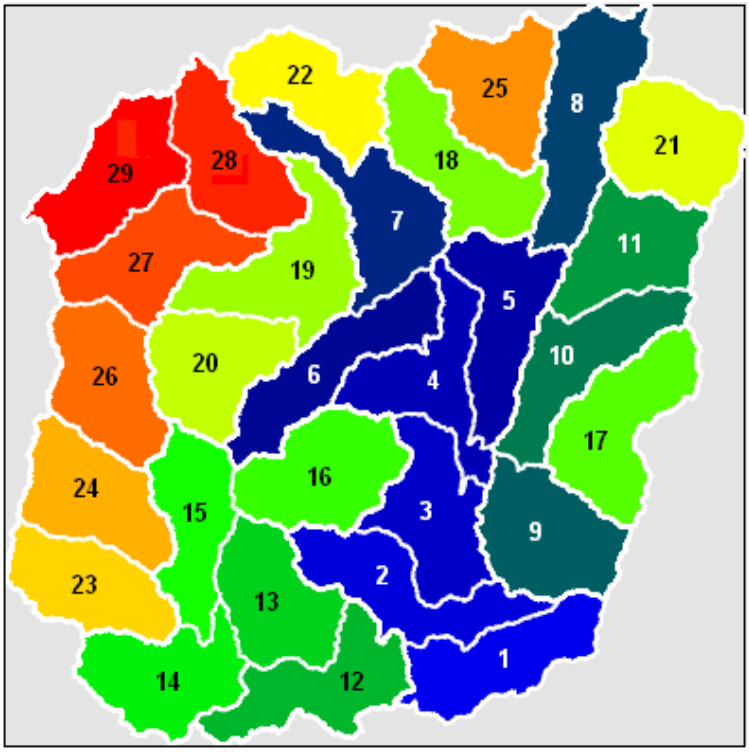

Figure 3.36: Meshes for the conditioned catchment

The maps for the outlets from the **SUBBASENAME_Outlet1** to **SUBBASENAME_Outlet19** files are combined and shown in the following figure (note that the map for an outlet is just the upstream area for that outlet in the mesh it is located in; other upstream meshes of the outlet are not included in the outlet map):

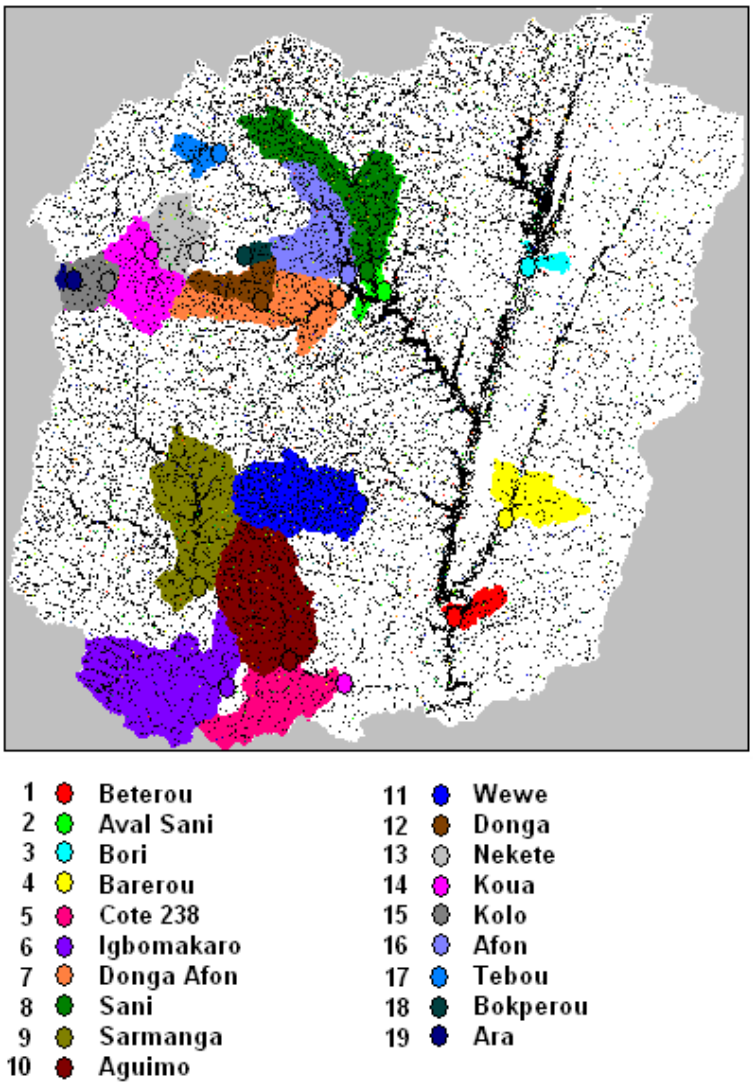

Figure 3.37: Outlet maps for the conditioned catchment

Chapter 4

Create Mesh for the Catchment - Sample Screens

4.1 FillSink Program for Raw Catchment

Sample screens for each program are given for the **Ohhvo** catchment in Benin, Africa. Items in red indicate entries typed in by the user.

An example screen for the FillSink program when the mesh units type is decimal degrees:

```
$ ./fillsink.exe


------------------------------------------------
------------------------------------------------
---                                          ---
---  F i l l   S i n k                       ---
---                                          ---
---                                          ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : February 2001       ---
------------------------------------------------
------------------------------------------------


 --- Input basename of the catchment : ../data/ohhvo_d
 --- Input units of the dtm mesh size (m = meters, d = degrees) : d

 --- Open files :
     + ../data/ohhvo_d.dtm

 --- Create files :
     + ../data/ohhvo_d_FilledDTM.map
     + ../data/ohhvo_d_FilledDTM_diff.map
     + ../data/ohhvo_d_FilledDTM_diff.dis

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9766670
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1459
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           223.00
     + Maximal value                 :           644.00
     + Reading ...                                 Done

 --- Initialize Initial Elevation Matrix :         Done

 --- Filling Sink ...
     + Iteration n°        888 Nb of Sinks :          0 (  0.0 %)

 --- Writing Filled Topography :
     + Writing ...                                 Done


 --- Writing Differences Elevation Map :
     + Initialise                                  Done
     + Writing ...                                 Done


 --- Writing Differences Elevation Distribution :
     + Writing ...                                 Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 4.1: Sample screen for FillSink program for raw catchment, mesh units in degrees

An example screen for the FillSink program when the mesh units type is meters:

```
$ ./fillsink.exe

------------------------------------------------
------------------------------------------------
---                                          ---
---  F i l l   S i n k                       ---
---                                          ---
---                                          ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : February 2001       ---
------------------------------------------------
------------------------------------------------


 --- Input basename of the catchment : ohhvo
 --- Input units of the dtm mesh size (m = meters, d = degrees) : m

 --- Open files :
     + ohhvo.dtm

 --- Create files :
     + ohhvo_FilledDTM.map
     + ohhvo_FilledDTM_diff.map
     + ohhvo_FilledDTM_diff.dis

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        333671.13
     + Ordinate bottom-left pixel    :        992652.31
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1459
     + Outside value                 :            -1.00
     + Mesh size (meters)            :            91.80
     + Minimal value                 :           223.00
     + Maximal value                 :           644.00
     + Reading ...                                Done

 --- Initialize Initial Elevation Matrix :        Done

 --- Filling Sink ...
     + Iteration n°       888 Nb of Sinks :          0 (  0.0 %)

 --- Writing Filled Topography :
     + Writing ...                                Done


 --- Writing Differences Elevation Map :
     + Initialise                                 Done
     + Writing ...                                Done


 --- Writing Differences Elevation Distribution :
     + Writing ...                                Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 4.2: Sample screen for FillSink program for raw catchment, mesh units in meters

4.2 Connections Program for Raw Catchment

The remaining screen samples are for mesh units in decimal degrees.

```
$ ./connections


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  CONNECTION CALCULATIONS                  ---
---                                           ---
---                                           ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment : ../data/ohhvo_d

 --- Open files :
     + ../data/ohhvo_d_FilledDTM.map

 --- Create files :
     + ../data/ohhvo_d_Sorted_MonoD.vec
     + ../data/ohhvo_d_Sorted_MultiD.vec

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9766670
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1459
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           228.00
     + Maximal value                 :           644.00
     + Reading ...                                Done

 --- Calculate Connections (MONO Directional scheme)
     + Initializing                  :             Done
     + Nb of pixels in the catchment :          2308136
     + Calculating                   :             Done
     + Sorting                       :             Done

 --- Write Sorted output file        :             Done

 --- Calculate Connections (MULTI Directional scheme)
     + Initializing                  :             Done
     + Nb of pixels in the catchment :          2308136
     + Calculating                   :             Done
     + Sorting                       :             Done

 --- Write Sorted output file        :             Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 4.3: Sample screen for Connections program for raw catchment

4.3 Index_MonoD Program for Raw Catchment

```
$ ./index_monod

-------------------------------------------------
-------------------------------------------------
---                                           ---
---  SIMILARITY INDEX CALCULATION             ---
---                                           ---
---  MONO Directional scheme                  ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/ohhvo_d

 --- River parameters :
     + Input the Drainage Area threshold           : 160000
     + Input the Topographic Index threshold       : 5

 --- Open files :
     + ../data/ohhvo_d_FilledDTM.map
     + ../data/ohhvo_d_Sorted_MonoD.vec

 --- Create files :
     + ../data/ohhvo_d_A_MonoD.map
     + ../data/ohhvo_d_ATB_MonoD.map
     + ../data/ohhvo_d_ATB_MonoD.dis
     + ../data/ohhvo_d_ATB_MonoD.vec
     + ../data/ohhvo_d_A_River_MonoD.map
     + ../data/ohhvo_d_ATB_River_MonoD.map
     + ../data/ohhvo_d_ATB_River_MonoD.dis
     + ../data/ohhvo_d_ATB_River_MonoD.vec
     + ../data/ohhvo_d_Sorted_River_MonoD.vec
     + ../data/ohhvo_d_River_MonoD.map
     + ../data/ohhvo_d_River_MonoD.vec
     + ../data/ohhvo_d_ARiver_MonoD.map

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9766670
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1459
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           228.00
     + Maximal value                 :           644.00
     + Reading ...                                 Done

 --- Read the Connection file
     + Number of pixels              :          2308136
     + Number of abscissa            :             1582
     + Number of ordinates           :             1459
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :           228.00
     + Maximal Elevation (m)         :           644.00
     + Reading ...                                 Done

 --- Initializing (1/3)                            Done
 --- Initializing (2/3)                            Done
 --- Initializing (3/3)                            Done

 --- Calculate DownFlow Slope ...                  Done
 -------------------------------------------------
 / W A R N I N G :                               /
 /       1003 TanB needed to be estimate from upslope/
 / pixels instead of downslope pixels            /
 ------------------------------------------------- Done
```

Figure 4.4: Sample screen for Index_MonoD program for raw catchment (part 1 of 2)

```
------------------------------------------------
Calculation WITHOUT TAKING the river into account
------------------------------------------------

--- Drainage Area
    + Minimal Drainage Area  (m2)   :         8427.240
    + Maximal Drainage Area (km2)   :        14354.648
    + Writing ...                                Done


--- Topographic Index
    + Calculate Topographic Index Map            Done
    + Writing ...                                Done

    + Calculate Topographic Index distrib.       Done
    + Write Topographic Index Vector             Done
    + Minimal Topographic Index     :           4.620
    + Maximal Topographic Index     :          27.778

------------------------------------------------
Calculation     TAKING     the river into account
------------------------------------------------

--- Drainage Area
    + Calculate Drainage Area Map                Done
    + Minimal Drainage Area  (m2)   :         4213.620
    + Maximal Drainage Area (km2)   :       522488.906
    + Writing ...                                Done


--- Topographic Index
    + Writing ...                                Done

    + Calculate Topographic Index distrib.       Done
    + Write Topographic Index Vector             Done
    + Minimal Topographic Index     :           4.620
    + Maximal Topographic Index     :          17.423

--- River Network
    + Writing ...                                Done

    + Writing Updated Connection file            Done
    + Calculate River connections                95 %
    + Writing ...                                Done

    + Write River Network Connection File        Done

>-----------------------------------<<<
>                                   <<<
> Program successfully terminated. <<<
>                                   <<<
>-----------------------------------<<<
```

Figure 4.5: Sample screen for Index_MonoDpProgram for raw catchment (part 2 of 2)

4.4 Mask2 Program for Conditioned Catchment

```
$ ./mask2


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  M a s k   b u i l d i n g                ---
---                                           ---
---  Calculate SubCatchment Mask              ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : August 1999          ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment    : ../data/ohhvo_d
 --- Input basename of the mask         : ../data/ohhvomask_d

 --- Open files :
     + ../data/ohhvo_d_FilledDTM.map
     + ../data/ohhvo_d_Sorted_MonoD.vec

 --- Create files :
     + ../data/ohhvomask_d.mask

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9766670
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1459
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :           228.00
     + Maximal value                 :           644.00
     + Reading ...                                 Done

 --- Read Connection Vector :
     + Number of pixels              :          2308136
     + Number of abscissa            :             1582
     + Number of ordinates           :             1459
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal Elevation (m)         :           228.00
     + Maximal Elevation (m)         :           644.00
     + Reading ...                                 Done

 --- Calculate Mask :
     + choose your coordinates system
       1=MAP file, 2=BMP, 3=Geographic               : 1
     + Input X and Y of Outlet                       : 878,67
     + Initialize                    :             Done
     + Exploring upslopes pixels     :
       Iteration 2104 Nb Sub Pixels  1698165 Surface 14310.84 km²
     + Initializing                  :             Done
 --- Get Origin Coordinates          :             Done
 --- Calculate Mask DTM              :              0 %
     + Writing ...                                 Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 4.6: Sample screen for Mask2 program for conditioned catchment

4.5 Extract Program for Conditioned Catchment

```
$ ./extract.exe


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  E x t r a c t                            ---
---                                           ---
---  Extract Using SubCatchment Mask          ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : August 1999          ---
-------------------------------------------------
-------------------------------------------------



 --- Input basename of the catchment    : ../data/ohhvo_d
 --- Input basename of the mask         : ../data/ohhvomask_d
 --- Input basename of the subcatchment : ../data/ohhvosub_d

 --- Open files :
     + ../data/ohhvo_d_FilledDTM.map
     + ../data/ohhvomask_d.mask

 --- Create files :
     + ../data/ohhvosub_d.mask
     + ../data/ohhvosub_d_FilledDTM.map

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9766670
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1459
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           228.00
     + Maximal value                 :           644.00
     + Reading ...                                 Done

 --- Read Mask Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9766670
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1459
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :             1.00
     + Reading ...                                 Done

 --- Look for Mask Dimensions        :             Done
 --- Calculate Extracted DTM         :             Done

 --- Write Extracted DTM :

     + Writing ...                                 Done


 --- Write Mask of the Extracted DTM :

     + Writing ...                                 Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 4.7: Sample screen for Extract program for conditioned catchment

4.6 Connections Program for Conditioned Catchment

```
$ ./connections.exe

-------------------------------------------------
-------------------------------------------------
---                                           ---
---  CONNECTION CALCULATIONS                  ---
---                                           ---
---                                           ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment : ../data/ohhvosub_d

 --- Open files :
     + ../data/ohhvosub_d_FilledDTM.map

 --- Create files :
     + ../data/ohhvosub_d_Sorted_MonoD.vec
     + ../data/ohhvosub_d_Sorted_MultiD.vec

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80  meters)
     + Minimal value                 :           236.30
     + Maximal value                 :           617.00
     + Reading ...                   :             Done

 --- Calculate Connections (MONO Directional scheme)
     + Initializing                  :             Done
     + Nb of pixels in the catchment :          1698165
     + Calculating                   :             Done
     + Sorting                       :             Done

 --- Write Sorted output file        :             Done

 --- Calculate Connections (MULTI Directional scheme)
     + Initializing                  :             Done
     + Nb of pixels in the catchment :          1698165
     + Calculating                   :             Done
     + Sorting                       :             Done

 --- Write Sorted output file        :             Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 4.8: Sample screen for Connections Program for conditioned catchment

4.7 Index_MonoD Program for Conditioned Catchment

```
$ ./index_monod.exe

-------------------------------------------------
-------------------------------------------------
---                                           ---
---  SIMILARITY INDEX CALCULATION             ---
---                                           ---
---  MONO Directional scheme                  ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/ohhvosub_d

 --- River parameters :
     + Input the Drainage Area threshold           : 160000
     + Input the Topographic Index threshold       : 5

 --- Open files :
     + ../data/ohhvosub_d_FilledDTM.map
     + ../data/ohhvosub_d_Sorted_MonoD.vec

 --- Create files :
     + ../data/ohhvosub_d_A_MonoD.map
     + ../data/ohhvosub_d_ATB_MonoD.map
     + ../data/ohhvosub_d_ATB_MonoD.dis
     + ../data/ohhvosub_d_ATB_MonoD.vec
     + ../data/ohhvosub_d_A_River_MonoD.map
     + ../data/ohhvosub_d_ATB_River_MonoD.map
     + ../data/ohhvosub_d_ATB_River_MonoD.dis
     + ../data/ohhvosub_d_ATB_River_MonoD.vec
     + ../data/ohhvosub_d_Sorted_River_MonoD.vec
     + ../data/ohhvosub_d_River_MonoD.map
     + ../data/ohhvosub_d_River_MonoD.vec
     + ../data/ohhvosub_d_ARiver_MonoD.map

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :           236.30
     + Maximal value                 :           617.00
     + Reading ...                                 Done

 --- Read the Connection file
     + Number of pixels              :          1698165
     + Number of abscissa            :             1582
     + Number of ordinates           :             1458
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal Elevation (m)         :           236.30
     + Maximal Elevation (m)         :           617.00
     + Reading ...                                 Done

 --- Initializing (1/3)                            Done
 --- Initializing (2/3)                            Done
 --- Initializing (3/3)                            Done


 --- Calculate DownFlow Slope ...                  Done
 -------------------------------------------------------
 / W A R N I N G :                                     /
 /          1 TanB needed to be estimate from upslope/
 / pixels instead of downslope pixels                  /
 -------------------------------------------------------
```

Figure 4.9: Sample screen for Index_MonoD Program for conditioned catchment (part 1 of 2)

```
------------------------------------------------
Calculation WITHOUT TAKING the river into account
------------------------------------------------

--- Drainage Area
    + Minimal Drainage Area  (m2)   :          8427.240
    + Maximal Drainage Area (km2)   :         14310.760
    + Writing ...                                  Done


--- Topographic Index
    + Calculate Topographic Index Map              Done
    + Writing ...                                  Done

    + Calculate Topographic Index distrib.         Done
    + Write Topographic Index Vector               Done
    + Minimal Topographic Index     :             4.620
    + Maximal Topographic Index     :            27.505

------------------------------------------------
Calculation     TAKING     the river into account
------------------------------------------------

--- Drainage Area
    + Calculate Drainage Area Map                  Done
    + Minimal Drainage Area  (m2)   :          4213.620
    + Maximal Drainage Area (km2)   :        522488.906
    + Writing ...                                  Done


--- Topographic Index
    + Writing ...                                  Done

    + Calculate Topographic Index distrib.         Done
    + Write Topographic Index Vector               Done
    + Minimal Topographic Index     :             4.620
    + Maximal Topographic Index     :            17.423

--- River Network
    + Writing ...                                  Done

    + Writing Updated Connection file              Done
    + Calculate River connections                  95 %
    + Writing ...                                  Done

    + Write River Network Connection File          Done

>----------------------------------<<<
>                                  <<<
> Program successfully terminated. <<<
>                                  <<<
>----------------------------------<<<
```

Figure 4.10: Sample screen for Index_MonoD Program for conditioned catchment (part 2 of 2)

4.8 Index_MultiD Program for Conditioned Catchment

```
$ ./index_multid.exe

-------------------------------------------------
-------------------------------------------------
---                                           ---
---  SIMILARITY INDEX CALCULATION             ---
---                                           ---
---  MULTI Directional scheme                 ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/ohhvosub_d

 --- Open files :
     + ../data/ohhvosub_d_FilledDTM.map
     + ../data/ohhvosub_d_Sorted_MultiD.vec
     + ../data/ohhvosub_d_River_MonoD.map

 --- Create files :
     + ../data/ohhvosub_d_A_MultiD.map
     + ../data/ohhvosub_d_ATB_MultiD.map
     + ../data/ohhvosub_d_ATB_MultiD.dis
     + ../data/ohhvosub_d_ATB_MultiD.vec
     + ../data/ohhvosub_d_A_River_MultiD.map
     + ../data/ohhvosub_d_ATB_River_MultiD.map
     + ../data/ohhvosub_d_ATB_River_MultiD.dis
     + ../data/ohhvosub_d_ATB_River_MultiD.vec
     + ../data/ohhvosub_d_Sorted_River_MultiD.vec

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           236.30
     + Maximal value                 :           617.00
     + Reading ...                                 Done

 --- Read the Connection file
     + Number of pixels              :          1698165
     + Number of abscissa            :             1582
     + Number of ordinates           :             1458
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :           236.30
     + Maximal Elevation (m)         :           617.00
     + Reading ...                                 Done

 --- Read the Connection file
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :             3.00
     + Reading ...                                 Done


 --- Initializing (1/3)                            Done
 --- Initializing (2/3)                            Done
 --- Initializing (3/3)                            Done

 --- Calculate DownFlow Slope ...                  Done
```

Figure 4.11: Sample screen for Index_MultiD Program for conditioned catchment (part 1 of 2)

```
-------------------------------------------------
/ W A R N I N G :                                /
/          1 TanB needed to be estimate from upslope/
/ pixels instead of downslope pixels             /
-------------------------------------------------

-----------------------------------------------
Calculation WITHOUT TAKING the river into account
-----------------------------------------------

--- Drainage Area
    + Minimal Drainage Area  (m2)   :         8427.240
    + Maximal Drainage Area (km2)   :        14310.651
    + Writing ...                                Done


--- Topographic Index
    + Calculate Topographic Index Map            Done
    + Writing ...                                Done

    + Calculate Topographic Index distrib.       Done
    + Write Topographic Index Vector             Done
    + Minimal Topographic Index     :           3.857
    + Maximal Topographic Index     :          27.650

-----------------------------------------------
Calculation     TAKING     the river into account
-----------------------------------------------

--- Drainage Area
    + Calculate Drainage Area Map                Done
    + Minimal Drainage Area  (m2)   :         4213.620
    + Maximal Drainage Area (km2)   :       361288.094
    + Writing ...                                Done


--- Topographic Index
    + Writing ...                                Done

    + Calculate Topographic Index distrib.       Done
    + Write Topographic Index Vector             Done
    + Minimal Topographic Index     :           3.857
    + Maximal Topographic Index     :          17.008
    + Writing Updated Connection file            Done

>----------------------------------<<<
>                                  <<<
> Program successfully terminated. <<<
>                                  <<<
>----------------------------------<<<
```

Figure 4.12: Sample screen for Index_MultiD Program for conditioned catchment (part 2 of 2)

4.9 Outlet_Coordinates Program for Conditioned Catchment

```
$ ./outlet_coordinates.exe


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  O u t l e t  C o o r d i n a t e s       ---
---                                           ---
---                                           ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : August 1999          ---
-------------------------------------------------
-------------------------------------------------




 --- Input basename of the catchment               : ../data/ohhvosub_d

 --- Do you want to read the coordinates from file Coordinates.list?
     (y = yes, n = no)                             : y

     Results on screen (0) or in file  (1)         : 1

     Name of the output file                       : ohhvosub_d_outlets.out

 --- Open files    :
     + ../data/ohhvosub_d_ARiver_MonoD.map
     + Coordinates.list

 --- Create file   :
     + Outlets.list
     + ohhvosub_d_outlets.out

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :   14310759424.00
     + Reading ...                                Done

 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 4.13: Sample screen for Outlet_Coordinates Program for conditioned catchment

4.10 Distances Program for Conditioned Catchment

```
$ ./distances.exe


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  D i s t a n c e s                        ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/ohhvosub_d

 --- Open files :
     + ../data/ohhvosub_d_FilledDTM.map
     + ../data/ohhvosub_d_River_MonoD.map

 --- Create files :
     + ../data/ohhvosub_d_Hillslope_Distance.map
     + ../data/ohhvosub_d_River_Distance.map

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           236.30
     + Maximal value                 :           617.00
     + Reading ...                                 Done

 --- Read River Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :             3.00
     + Reading ...                                 Done

 --- Calculate Hillslope and River Distances Done

 --- Write Hillslope Distance Map
     + Writing ...                                 Done


 --- Write River Distance Map
     + Writing ...                                 Done

 >-----------------------------------<<<
 >                                   <<<
 > Program successfully terminated.  <<<
 >                                   <<<
 >-----------------------------------<<<
```

Figure 4.14: Sample screen for Distances Program for conditioned catchment

4.11 Geomorpho Program for Conditioned Catchment

```
$ ./geomorpho.exe

------------------------------------------------
------------------------------------------------
---                                          ---
---  G e o m o r p h o                       ---
---                                          ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : February 2001       ---
------------------------------------------------
------------------------------------------------


 --- Input basename of the catchment               : ../data/ohhvosub_d

 --- Open files :
     + ../data/ohhvosub_d_Hillslope_Distance.map
     + ../data/ohhvosub_d_River_Distance.map
     + ../data/ohhvosub_d_ATB_River_MultiD.map
     + ../data/ohhvosub_d_River_MonoD.map

 --- Create files :
     + ../data/ohhvosub_d_GeomorphoFT.vec
     + ../data/ohhvosub_d_GeomorphoISO.vec

 --- Read Hillslope distances Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :          1828.13
     + Reading ...                                 Done

 --- Read River Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :            45.90
     + Maximal value                 :       232985.50
     + Reading ...                                 Done

 --- Read ATB Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :         -9999.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :             3.86
     + Maximal value                 :            17.01
     + Reading ...                                 Done

 --- Read River Network Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :             3.00
     + Reading ...                                 Done
```

Figure 4.15: Sample screen for Geomorpho Program for conditioned catchment (part 1 of 2)

```
--- Input Velocity (m/s) for :
    + River                          : .6
    + Hillslope                      : .06

--- Input Ac Threshold (0 < x < 1)   : .5

--- Input Time Step (s)              : 10

--- Loop on pixels                          Done
    + Nb pixels considered           :     845046
    + Maximum delay (h)              :     111.78
    + Nb pixels river                :     206381
    + Maximum delay (h)              :     107.82

--- Write Time Distribution for Transfer Function

--- Write Time Distribution for Isochrones

>-----------------------------------<<<
>                                   <<<
> Program successfully terminated. <<<
>                                   <<<
>-----------------------------------<<<
```

Figure 4.16: Sample screen for Geomorpho Program for conditioned catchment (part 2 of 2)

4.12 Input_Mesh Program for Conditioned Catchment

```
$ ./input_mesh.exe

-------------------------------------------------
-------------------------------------------------
---                                           ---
---  I n p u t    M e s h                     ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/ohhvosub_d

 --- Open files :
     + ../data/ohhvosub_d_River_MonoD.vec
     + ../data/ohhvosub_d_ARiver_MonoD.map

 --- Create files :
     + ../data/ohhvosub_d_Mesh0.vec

 --- Read the River Connection file
     + Number of pixels              :          206381
     + Number of abscissa            :            1582
     + Number of ordinates           :            1458
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :          236.30
     + Maximal Elevation (m)         :          525.00
     + Reading ...                                Done

 --- Read River Drainage Area Map
     + Abscissa bottom-left pixel    :       1.4866670
     + Ordinate bottom-left pixel    :       8.9775003
     + Nb Abscissa                   :            1582
     + Nb Ordinates                  :            1458
     + Outside value                 :           -1.00
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal value                 :            0.00
     + Maximal value                 :   14310759424.00
     + Reading ...                                Done

 --- Build input mesh file                        Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 4.17: Sample screen for Input_Mesh Program for conditioned catchment

4.13 Define_Mesh Program for Conditioned Catchment

```
$ ./define_mesh.exe


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  D e f i n e    M e s h                   ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/ohhvosub_d

 --- Open files :
     + ../data/ohhvosub_d_River_MonoD.vec
     + ../data/ohhvosub_d_Mesh0.vec
     + ../data/ohhvosub_d_FilledDTM.map

 --- Create files :
     + ../data/ohhvosub_d_Mesh.coord

 --- Read the River Connection file
     + Number of pixels              :          206381
     + Number of abscissa            :            1582
     + Number of ordinates           :            1458
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :          236.30
     + Maximal Elevation (m)         :          525.00
     + Reading ...                                Done

 --- Read the Input Mesh file                      Done

 --- Read the Input Mesh file
     + Abscissa bottom-left pixel    :       1.4866670
     + Ordinate bottom-left pixel    :       8.9775003
     + Nb Abscissa                   :            1582
     + Nb Ordinates                  :            1458
     + Outside value                 :           -1.00
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal value                 :          236.30
     + Maximal value                 :          617.00
     + Reading ...                                Done

 --- Detect position of Fixed Outlets
     for hydrological modelling ('y' or 'n')?Y

 --- Open file ../data/Outlets.list

 --- Calculate river Strahler orders
     + Nombre de confluences:       37777
     + Ordre de Strahler maximum:       8

 --- Nominal area of meshes (km²) : 500

 --- Mesh watershed(1) or geographic area(2) ? 1

          + Revised nominal area (km²) :     493.47

          + Approx number of meshes    :       29
        + Mesh nº   1:  488.48 km²
        + Mesh nº   2:  481.43 km²
        + Mesh nº   3:  496.58 km²
        + Mesh nº   4:  494.33 km²
        + Mesh nº   5:  495.73 km²
        + Mesh nº   6:  491.48 km²
        + Mesh nº   7:  440.24 km²
        + Mesh nº   8:  442.89 km²
        + Mesh nº   9:  492.85 km²
        + Mesh nº  10:  478.52 km²
```

Figure 4.18: Sample screen for Define_Mesh Program for conditioned catchment (part 1 of 2)

```
        + Mesh n°  11:  554.60 km²
        + Mesh n°  12:  497.55 km²
        + Mesh n°  13:  556.95 km²
        + Mesh n°  14:  535.52 km²
        + Mesh n°  15:  431.85 km²
        + Mesh n°  16:  493.15 km²
        + Mesh n°  17:  470.00 km²
        + Mesh n°  18:  486.55 km²
        + Mesh n°  19:  462.33 km²
        + Mesh n°  20:  488.05 km²
        + Mesh n°  21:  528.27 km²
        + Mesh n°  22:  580.02 km²
        + Mesh n°  23:  529.94 km²
        + Mesh n°  24:  493.23 km²
        + Mesh n°  25:  482.26 km²
        + Mesh n°  26:  464.04 km²
        + Mesh n°  27:  486.54 km²
        + Mesh n°  28:  493.50 km²
        + Mesh n°  29:  473.86 km²

--- Total area : 14310.76 km²

--- rmse criterion on mesh areas:  33.33
--- Mean Bias on mesh areas     :  -0.00 %
--- Max Bias on mesh areas      :  17.54 %

--- Calculate outlets coordinates

--- Write coordinates file

--- Create file Outlets.list.updated




>>>-----------------------------------<<<
>>>                                   <<<
>>> Program successfully terminated. <<<
>>>                                   <<<
>>>-----------------------------------<<<
```

Figure 4.19: Sample screen for Define_Mesh Program for conditioned catchment (part 2 of 2)

4.14 Draw_Mesh Program for Conditioned Catchment

```
$ ./draw_mesh.exe

------------------------------------------------
------------------------------------------------
---                                          ---
---  D r a w    M e s h                      ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : February 2001       ---
------------------------------------------------
------------------------------------------------


 --- Input the basename of the catchment    : ../data/ohhvosub_d

 --- Open files :
     + ../data/ohhvosub_d_FilledDTM.map
     + ../data/ohhvosub_d_Sorted_MonoD.vec
     + ../data/ohhvosub_d_Mesh.coord

 --- Create files :
     + ../data/ohhvosub_d_Mesh_Coord.Map

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal value                 :           236.30
     + Maximal value                 :           617.00
     + Reading ...                                 Done

 --- Read Connection Vector :
     + Number of pixels              :          1698165
     + Number of abscissa            :             1582
     + Number of ordinates           :             1458
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :           236.30
     + Maximal Elevation (m)         :           617.00
     + Reading ...                                 Done

 --- Read Mesh coordinates file:
     +   29 meshes read

 --- Take into account Fixed Outlets
     for hydrological modelling ('y' or 'n')?y

 --- Open file ../data/Outlets.list.updated


 --- Calculate Mask :
     + Initialize                    :              Done
     + Exploring upslopes pixels     :
       Iteration 2104 Nb Sub Pixels  1698165 Surface 14310.84  km²
     + Initialize                    :              Done

     ...

     + Initialize                    :              Done
     + Exploring upslopes pixels     :
       Iteration   70 Nb Sub Pixels     1495 Surface    12.60  km²
     + Writing ...                                 Done


>>>-----------------------------------<<<
>>>                                   <<<
>>> Program successfully terminated. <<<
>>>                                   <<<
>>>-----------------------------------<<<
```

Figure 4.20: Sample screen for Draw_Mesh Program for conditioned catchment

Chapter 5

Create Mesh for a Subcatchment

The following sections provide the sequence in which the pre-processing programs must be executed to create a subcatchment mesh. First *extract* the subcatchment from the conditioned catchment and run the programs for treatment of the subcatchment data. Then create the mesh files for the subcatchment.

5.1 Mask2 Program for the Donga Subcatchment

Prior to running this program, the conditioned catchment for the **Ohhvo** catchment must have been created. Then given the outlet coordinates for the Donga subcatchment, this program creates a mask file for this subcatchment.

5.1.1 User Entries

The following items are entered by the user:

- SUBBASENAME of the conditioned **Ohhvo** catchment
- DONGA_MASKNAME, mask name for the Donga subcatchment
- Coordinate system (1 = MAP file, 2 = BMP, 3 = Geographic)
  - For the MAP and BMP coordinate systems:
    Enter X,Y-coordinates of the outlet for the Donga subcatchment
  - For the Geographic coordinate system:
    Enter X,Y-coordinates of the outlet, and approximate drainage area (km^2)

5.1.2 Input Files

The files read by this program are shown in the following figure:

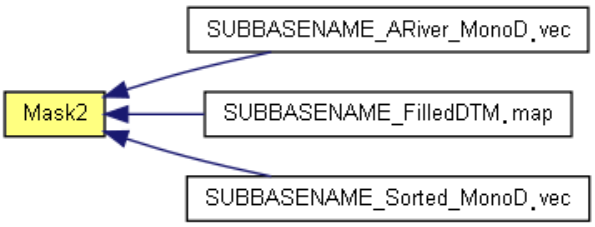

Figure 5.1: Files read by Mask2 program for the Donga subcatchment

5.1.3 Output File

The file written by this program is shown in the following figure:

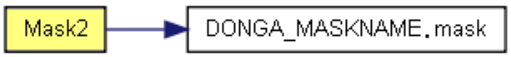

Figure 5.2: File written by Mask2 program for the Donga subcatchment

5.2 Extract Program for the Donga Subcatchment

Given the *mask* file for the Donga subcatchment, this program extracts a *DTM* file for this subcatchment from the conditioned catchment.

5.2.1 User Entries

The following items are entered by the user:

- SUBBASENAME of the conditioned catchment
- DONGA_MASKNAME for the Donga subcatchment
- DONGA_SUBBASENAME, subbasename for the Donga subcatchment

5.2.2 Input Files

The files read by this program are shown in the following figure:

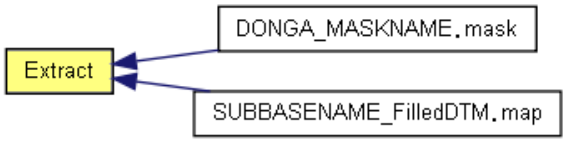

Figure 5.3: Files read by Extract program for the Donga subcatchment

5.2.3 Output Files

The files written by this program are shown in the following figure:

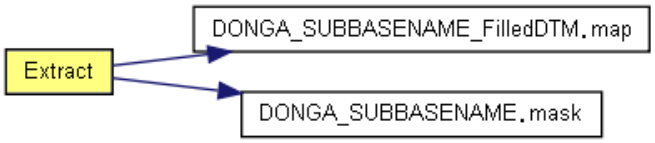

Figure 5.4: Files written by Extract program for the Donga subcatchment

5.3 Connections Program for the Donga subcatchment

This program sorts the Donga subcatchment DTM pixels by decreasing elevation.

5.3.1 User Entries

The following item is entered by the user:

- DONGA_SUBBASENAME of the subcatchment

5.3.2 Input File

The file read by this program is shown in the following figure:

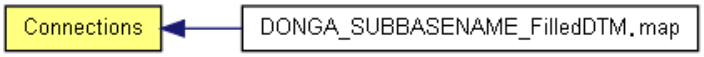

Figure 5.5: File read by Connections program for the Donga subcatchment

5.3.3 Output Files

The files written by this program are shown in the following figure:

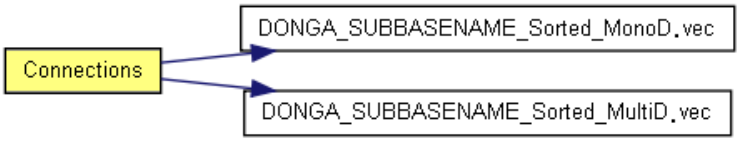

Figure 5.6: Files written by Connections program for the Donga subcatchment

5.4 Index_MonoD Program for the Donga subcatchment

This program calculates the mono-directional hydrographic network and topographic indexes for the Donga subcatchment.

5.4.1 User Entries

The following items are entered by the user:

- DONGA_SUBBASENAME of the subcatchment
- Drainage area threshold (m^2)
- Topographic index threshold

5.4.2 Input Files

The files read by this program are shown in the following figure:

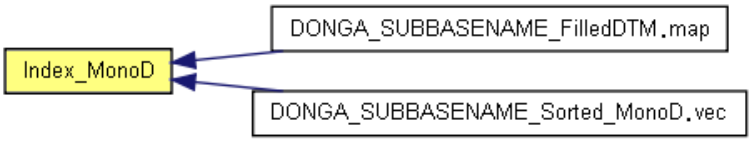

Figure 5.7: Files read by Index_MonoD program for the Donga subcatchment

5.4.3 Output Files

The files written by this program are shown in the following figure:

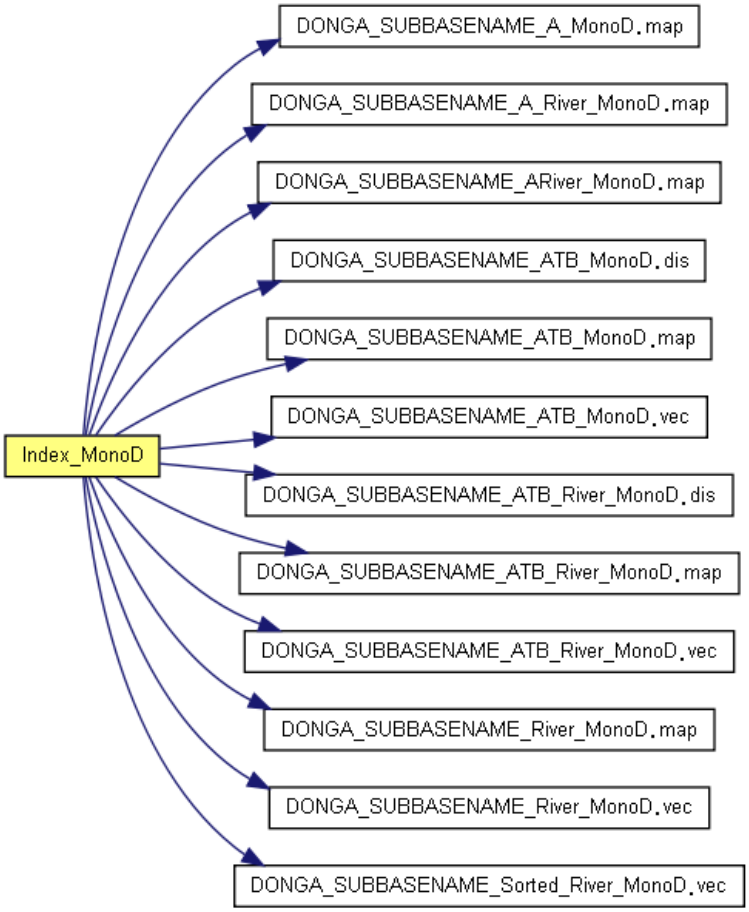

Figure 5.8: Files written by Index_MonoD program for the Donga subcatchment

5.5 Index_MultiD Program for the Donga subcatchment

This program calculates the multi-directional hydrographic network and topographic indexes for the Donga subcatchment.

5.5.1 User Entries

The following item is entered by the user:

- DONGA_SUBBASENAME of the Donga subcatchment

5.5.2 Input Files

The files read by this program are shown in the following figure:

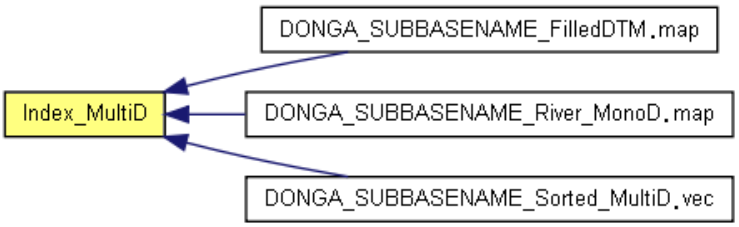

Figure 5.9: Files read by Index_MultiD program for the Donga subcatchment

5.5.3 Output Files

The files written by this program are shown in the following figure:

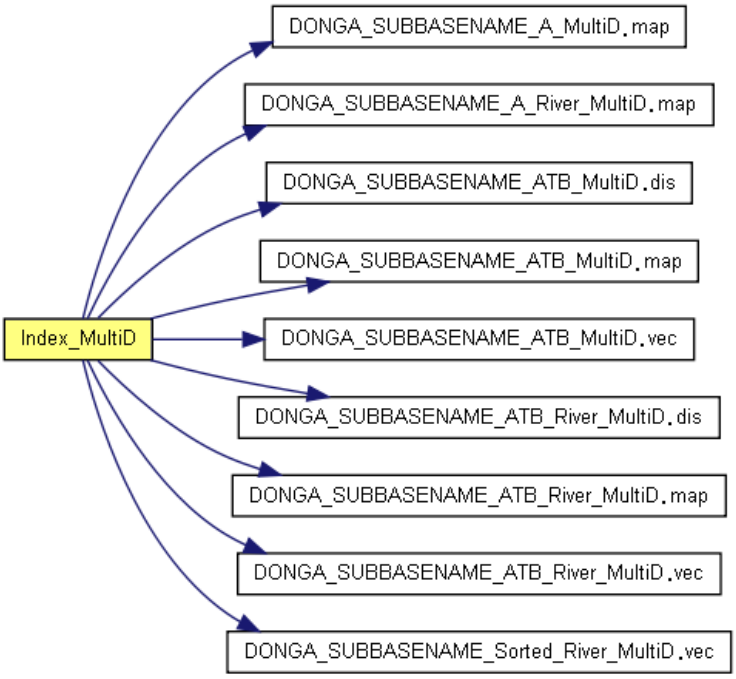

Figure 5.10: Files written by Index_MultiD program for the Donga subcatchment

5.6 Outlet_Coordinates Program for the Donga subcatchment

This program finds the nearest river pixel for the Donga subcatchment outlet coordinates.

5.6.1 User Entries

The following items are entered by the user:

- DONGA_SUBBASENAME of the catchment
- Option to read coordinates from file **Coordinates.list** ('y' = yes, 'n' = no)
- If not reading from the **Coordinates.list** file, enter:
  x-coordinate, y-coordinate, and drainage area (km^2)
- Specify whether to write results to screen (0) or file (1)
- If writing results to a file, enter 'UserFilename.ext'

5.6.2 Input Files

The files read by this program are shown in the following figure:

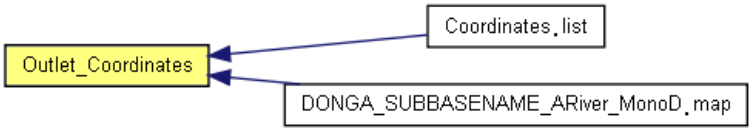

Figure 5.11: Files read by Outlet_Coordinates program for the Donga subcatchment

Sample input for the **Coordinates.list** file for the Donga subcatchment:

```
1.60990827    9.75223248        12.8     3      Ara
1.68654088    9.75201188         105     9      Kolo
1.94471126    9.71056822         586     6      Donga
```

5.6.3 Output Files

The files written by this program are shown in the following figure:

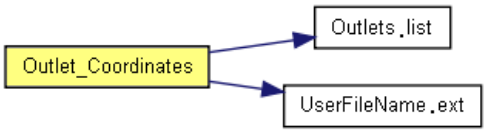

Figure 5.12: Files written by Outlet_Coordinates program for the Donga subcatchment

Outlets.list will be written to the same directory that the data files are in, and the user specified filename will be written to the executable directory unless a path is specified with the file name.

Sample output for the **Outlets.list** file for the Donga subcatchment:

```
  3
 51          116
142          116
452           67
```

Sample output for the **UserFileName.ext** file for the Donga subcatchment:

```
   Initial     Initial     Initial      Initial       Final       Final
 X degrees   Y degrees     X value      Y value     X value     Y value
 1.6099082   9.7522326   347523.99   1078332.24   347569.59   1078210.75  ...
 1.6865408   9.7520123   355930.99   1078274.26   355888.70   1078177.49
 1.9447112   9.7105684   384237.99   1073592.21   384212.72   1073563.04

 Init Col.  Init Line  Col.  Line BMP I BMP J Init Area      Area
...     50         117    51   116    50   173     12.80     12.60
       142         116   142   116   141   173    105.00    100.91
       452          67   452    67   451   222    586.00    584.44
```

5.7 Distances Program for the Donga subcatchment

This program calculates distances for each pixel in the Donga subcatchment. The two distances calculated for each pixel are:

1. the distance that water flows from that pixel to the river, and
2. the distance from that point at the river to the outlet.

5.7.1 User Entries

The following item is entered by the user:

- DONGA_SUBBASENAME of the subcatchment

5.7.2 Input Files

The files read by this program are shown in the following figure:

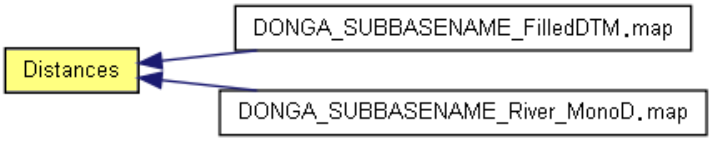

Figure 5.13: Files read by Distances program for the Donga subcatchment

5.7.3 Output Files

The files written by this program are shown in the following figure:

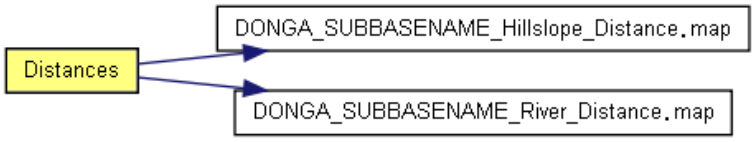

Figure 5.14: Files written by Distances program for the Donga subcatchment

5.8 Geomorpho Program for the Donga subcatchment

This program determines the geomorphic characteristics of the Donga subcatchment, and the transfer functions and paths for water to travel to the outlet, including both surface runoff and subsurface flow.

5.8.1 User Entries

The following items are entered by the user:

- DONGA_SUBBASENAME of the catchment
- Velocity for river (m/s)
- Velocity for hillslope (m/s)
- Ac Threshold ($0 < x < 1$)
- Time step (sec)

5.8.2 Input Files

The files read by this program are shown in the following figure:

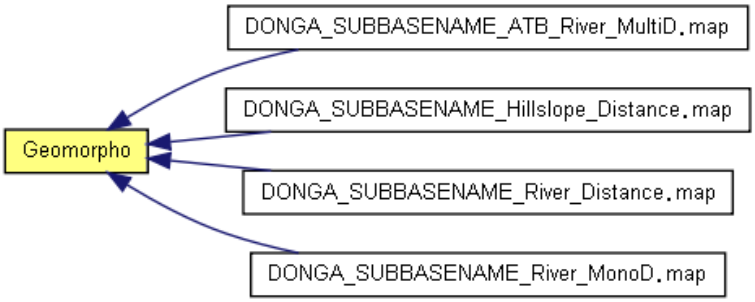

Figure 5.15: Files read by Geomorpho program for the Donga subcatchment

5.8.3 Output Files

The files written by this program are shown in the following figure:

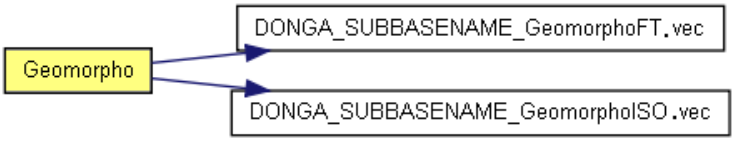

Figure 5.16: Files written by Geomorpho program for the Donga subcatchment

5.9 Input_Mesh for the Donga subcatchment

This program creates a data file for use by the **Define_Mesh** program to calculate the hydrologic mesh.

5.9.1 User Entries

The following item is entered by the user:

- DONGA_SUBBASENAME of the catchment

5.9.2 Input Files

The files read by this program are shown in the following figure:

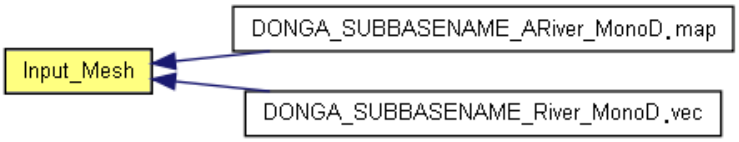

Figure 5.17: Files read by Input_Mesh program for the Donga subcatchment

5.9.3 Output File

The file written by this program is shown in the following figure:

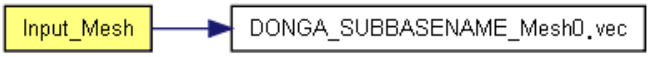

Figure 5.18: File written by Input_Mesh program for the Donga subcatchment

5.10 Define_Mesh for the Donga subcatchment

This program realizes the hydrologic mesh for a region. It does this by defining the coordinates of the outlets of the effective mesh from the fixed outlets specified in **Outlets.list**.

5.10.1 User Entries

The following items are entered by the user:

- DONGA_SUBBASENAME of the catchment
- Detect position of Fixed Outlets ('y' or 'n')

5.10.2 Input Files

The files read by this program are shown in the following figure:

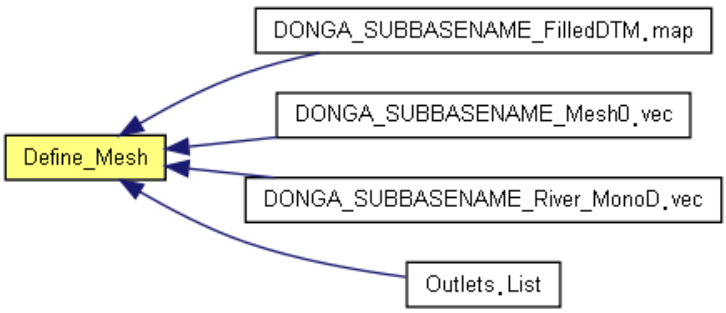

Figure 5.19: Files read by Define_Mesh program for the Donga subcatchment

5.10.3 Output Files

The files written by this program are shown in the following figure:

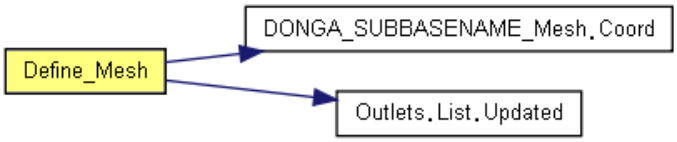

Figure 5.20: Files written by Define_Mesh program for the Donga subcatchment

5.11 Draw_Mesh for the Donga subcatchment

This program creates the mesh files for the Donga subcatchment.

5.11.1 User Entries

The following items are entered by the user:

- DONGA_SUBBASENAME of the catchment
- Detect position of Fixed Outlets ('y' or 'n')

5.11.2 Input File

The files read by this program are shown in the following figure:

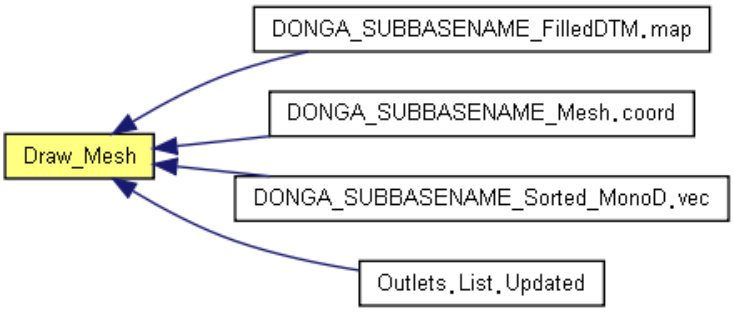

Figure 5.21: Files read by Draw_Mesh program for the Donga subcatchment

5.11.3 Output Files

The files written by this program are shown in the following figure:

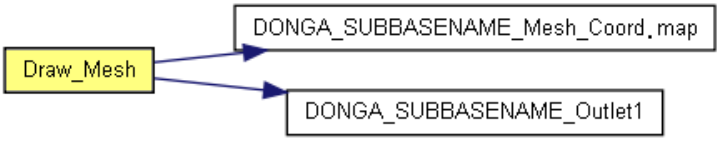

Figure 5.22: Files written by Draw_Mesh program for the Donga subcatchment

The meshes created by the Draw_Mesh program in the **DONGA_SUBBASENAME_Mesh_Coord.map** file are shown in the following figure:

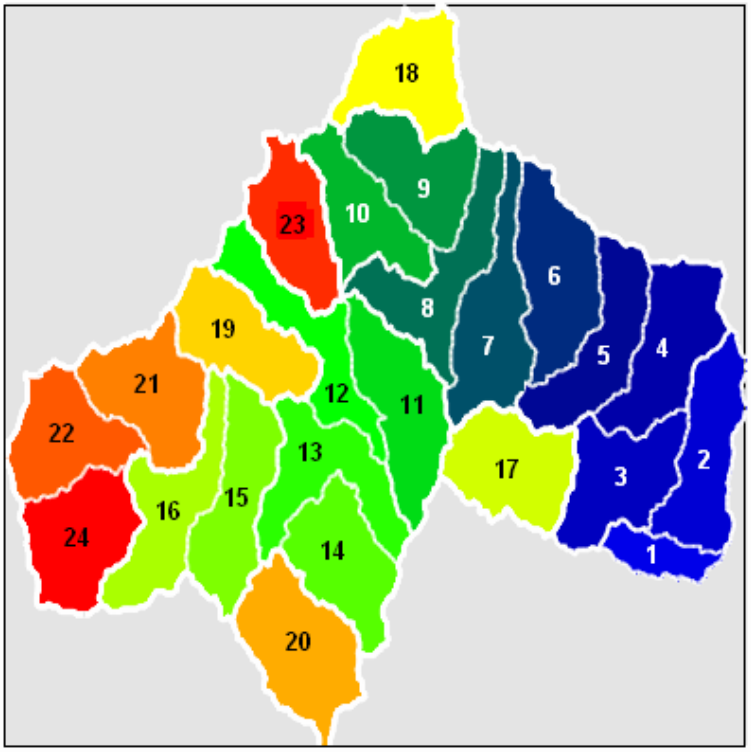

Figure 5.23: Meshes for the Donga subcatchment

Chapter 6

Create Mesh for a Subcatchment - Sample Screens

6.1 Mask2 Program for the Donga subcatchment

Sample screens for each program are given for creating the **Donga** subcatchment of the **Ohhvo** catchment in Benin, Africa. Items in red indicate entries typed in by the user.

```
$ ./mask2

------------------------------------------------
------------------------------------------------
---                                          ---
---  M a s k   b u i l d i n g               ---
---                                          ---
---  Calculate SubCatchment Mask             ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : August 1999         ---
------------------------------------------------
------------------------------------------------


 --- Input basename of the catchment    : ../data/ohhvosub_d
 --- Input basename of the mask         : ../data/dongamask

 --- Open files :
     + ../data/ohhvosub_d_FilledDTM.map
     + ../data/ohhvosub_d_Sorted_MonoD.vec

 --- Create files :
     + ../data/dongamask.mask

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           236.30
     + Maximal value                 :           617.00
     + Reading ...                               Done

 --- Read Connection Vector :
     + Number of pixels              :          1698165
     + Number of abscissa            :             1582
     + Number of ordinates           :             1458
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :           236.30
     + Maximal Elevation (m)         :           617.00
     + Reading ...                               Done

 --- Calculate Mask :
     + choose your coordinates system
       1=MAP file, 2=BMP, 3=Geographic               : 3
     + Input X,Y (m or deg) and Area (km2) of Outlet: 1.94471,9.71057,586

     >>> the coordinates in the MAP file system are :    551    881


 --- Open files    :
     + ohhvo_d_ARiver_MonoD.map

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :    14310759424.00
     + Reading ...                               Done

     >>> FIND closest river pixel...

     >>> the closest river pixel in the MAP is      :    550    880
```

Figure 6.1: Sample screen for Mask2 program for the Donga subcatchment (part 1 of 2)

```
    + Initialize                    :              Done
    + Exploring upslopes pixels     :
      Iteration  600 Nb Sub Pixels    69351 Surface   584.44 km²
    + Initializing                  :              Done

--- Get Origin Coordinates          :              Done
--- Calculate Mask DTM              :               0 %
    + Writing ...                                  Done

>>>-----------------------------------<<<
>>>                                   <<<
>>> Program successfully terminated. <<<
>>>                                   <<<
>>>-----------------------------------<<<
```

Figure 6.2: Sample screen for Mask2 program for the Donga subcatchment (part 2 of 2)

6.2 Extract Program for the Donga subcatchment

```
$ ./extract.exe


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  E x t r a c t                            ---
---                                           ---
---  Extract Using SubCatchment Mask          ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : August 1999          ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment    : ../data/ohhvosub_d
 --- Input basename of the mask         : ../data/dongamask
 --- Input basename of the subcatchment : ../data/donga

 --- Open files :
     + ../data/ohhvosub_d_FilledDTM.map
     + ../data/dongamask.mask

 --- Create files :
     + ../data/donga.mask
     + ../data/donga_FilledDTM.map

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           236.30
     + Maximal value                 :           617.00
     + Reading ...                                 Done

 --- Read Mask Map :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9775003
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1458
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :             1.00
     + Reading ...                                 Done

 --- Look for Mask Dimensions        :             Done
 --- Calculate Extracted DTM         :             Done

 --- Write Extracted DTM :

     + Writing ...                                 Done


 --- Write Mask of the Extracted DTM :

     + Writing ...                                 Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 6.3: Sample screen for Extract program for the Donga subcatchment

6.3 Connections Program for the Donga subcatchment

```
$ ./connections.exe


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  CONNECTION CALCULATIONS                  ---
---                                           ---
---                                           ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment : ../data/donga

 --- Open files :
     + ../data/donga_FilledDTM.map

 --- Create files :
     + ../data/donga_Sorted_MonoD.vec
     + ../data/donga_Sorted_MultiD.vec

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           327.65
     + Maximal value                 :           499.00
     + Reading ...                                Done

 --- Calculate Connections (MONO Directional scheme)
     + Initializing                  :             Done
     + Nb of pixels in the catchment :            69351
     + Calculating                   :             Done
     + Sorting                       :             Done

 --- Write Sorted output file        :             Done

 --- Calculate Connections (MULTI Directional scheme)
     + Initializing                  :             Done
     + Nb of pixels in the catchment :            69351
     + Calculating                   :             Done
     + Sorting                       :             Done

 --- Write Sorted output file        :             Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 6.4: Sample screen for Connections program for the Donga subcatchment

6.4 Index_MonoD Program for the Donga subcatchment

```
$ ./index_monod.exe

-------------------------------------------------
-------------------------------------------------
---                                           ---
---  SIMILARITY INDEX CALCULATION             ---
---                                           ---
---  MONO Directional scheme                  ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/donga

 --- River parameters :
     + Input the Drainage Area threshold           : 160000
     + Input the Topographic Index threshold       : 5

 --- Open files :
     + ../data/donga_FilledDTM.map
     + ../data/donga_Sorted_MonoD.vec

 --- Create files :
     + ../data/donga_A_MonoD.map
     + ../data/donga_ATB_MonoD.map
     + ../data/donga_ATB_MonoD.dis
     + ../data/donga_ATB_MonoD.vec
     + ../data/donga_A_River_MonoD.map
     + ../data/donga_ATB_River_MonoD.map
     + ../data/donga_ATB_River_MonoD.dis
     + ../data/donga_ATB_River_MonoD.vec
     + ../data/donga_Sorted_River_MonoD.vec
     + ../data/donga_River_MonoD.map
     + ../data/donga_River_MonoD.vec
     + ../data/donga_ARiver_MonoD.map

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :           -1.00
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal value                 :           327.65
     + Maximal value                 :           499.00
     + Reading ...                                 Done

 --- Read the Connection file
     + Number of pixels              :            69351
     + Number of abscissa            :              480
     + Number of ordinates           :              289
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :           327.65
     + Maximal Elevation (m)         :           499.00
     + Reading ...                                 Done

 --- Initializing (1/3)                            Done
 --- Initializing (2/3)                            Done
 --- Initializing (3/3)                            Done

 --- Calculate DownFlow Slope ...                  Done
 -------------------------------------------------------
 / W A R N I N G :                                     /
 /          1 TanB needed to be estimate from upslope/
 / pixels instead of downslope pixels                  /
 -------------------------------------------------------
```

Figure 6.5: Sample screen for Index_MonoD program for the Donga subcatchment (part 1 of 2)

```
-------------------------------------------------
Calculation WITHOUT TAKING the river into account
-------------------------------------------------

--- Drainage Area
    + Minimal Drainage Area  (m2)   :          8427.240
    + Maximal Drainage Area (km2)   :           584.435
    + Writing ...                                  Done


--- Topographic Index
    + Calculate Topographic Index Map              Done
    + Writing ...                                  Done

    + Calculate Topographic Index distrib.         Done
    + Write Topographic Index Vector               Done
    + Minimal Topographic Index     :             6.842
    + Maximal Topographic Index     :            24.541

-------------------------------------------------
Calculation     TAKING     the river into account
-------------------------------------------------

--- Drainage Area
    + Calculate Drainage Area Map                  Done
    + Minimal Drainage Area  (m2)   :          4213.620
    + Maximal Drainage Area  (m2)   :        421362.000
    + Writing ...                                  Done


--- Topographic Index
    + Writing ...                                  Done

    + Calculate Topographic Index distrib.         Done
    + Write Topographic Index Vector               Done
    + Minimal Topographic Index     :             6.842
    + Maximal Topographic Index     :            17.130

--- River Network
    + Writing ...                                  Done

    + Writing Updated Connection file              Done
    + Calculate River connections                  95 %
    + Writing ...                                  Done

    + Write River Network Connection File          Done

>-----------------------------------<<<
>                                   <<<
> Program successfully terminated. <<<
>                                   <<<
>-----------------------------------<<<
```

Figure 6.6: Sample screen for Index_MonoD program for the Donga subcatchment (part 2 of 2)

6.5 Index_MultiD Program for the Donga subcatchment

```
$ ./index_multid.exe

-------------------------------------------------
-------------------------------------------------
---                                           ---
---  SIMILARITY INDEX CALCULATION             ---
---                                           ---
---  MULTI Directional scheme                 ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/donga

 --- Open files :
     + ../data/donga_FilledDTM.map
     + ../data/donga_Sorted_MultiD.vec
     + ../data/donga_River_MonoD.map

 --- Create files :
     + ../data/donga_A_MultiD.map
     + ../data/donga_ATB_MultiD.map
     + ../data/donga_ATB_MultiD.dis
     + ../data/donga_ATB_MultiD.vec
     + ../data/donga_A_River_MultiD.map
     + ../data/donga_ATB_River_MultiD.map
     + ../data/donga_ATB_River_MultiD.dis
     + ../data/donga_ATB_River_MultiD.vec
     + ../data/donga_Sorted_River_MultiD.vec

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :           327.65
     + Maximal value                 :           499.00
     + Reading ...                                 Done

 --- Read the Connection file
     + Number of pixels              :            69351
     + Number of abscissa            :              480
     + Number of ordinates           :              289
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :           327.65
     + Maximal Elevation (m)         :           499.00
     + Reading ...                                 Done

 --- Read the Connection file
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :             3.00
     + Reading ...                                 Done

 --- Initializing (1/3)                            Done
 --- Initializing (2/3)                            Done
 --- Initializing (3/3)                            Done

 --- Calculate DownFlow Slope ...                  Done
```

Figure 6.7: Sample screen for Index_MultiD program for the Donga subcatchment (part 1 of 2)

```
-------------------------------------------------------
/ W A R N I N G :                                      /
/          1 TanB needed to be estimate from upslope/
/ pixels instead of downslope pixels                   /
-------------------------------------------------------

-------------------------------------------------
Calculation WITHOUT TAKING the river into account
-------------------------------------------------

--- Drainage Area
    + Minimal Drainage Area  (m2)   :          8427.240
    + Maximal Drainage Area (km2)   :           584.435
    + Writing ...                                  Done


--- Topographic Index
    + Calculate Topographic Index Map              Done
    + Writing ...                                  Done

    + Calculate Topographic Index distrib.         Done
    + Write Topographic Index Vector               Done
    + Minimal Topographic Index     :             5.841
    + Maximal Topographic Index     :            24.555

-------------------------------------------------
Calculation     TAKING     the river into account
-------------------------------------------------

--- Drainage Area
    + Calculate Drainage Area Map                  Done
    + Minimal Drainage Area  (m2)   :          4626.875
    + Maximal Drainage Area  (m2)   :        273476.688
    + Writing ...                                  Done


--- Topographic Index
    + Writing ...                                  Done

    + Calculate Topographic Index distrib.         Done
    + Write Topographic Index Vector               Done
    + Minimal Topographic Index     :             5.841
    + Maximal Topographic Index     :            16.554
    + Writing Updated Connection file              Done

>-----------------------------------<<<
>                                   <<<
> Program successfully terminated. <<<
>                                   <<<
>-----------------------------------<<<
```

Figure 6.8: Sample screen for Index_MultiD program for the Donga subcatchment (part 2 of 2)

6.6 Outlet_Coordinates Program for the Donga subcatchment

```
$ ./outlet_coordinates.exe


------------------------------------------------
------------------------------------------------
---                                          ---
---  O u t l e t  C o o r d i n a t e s      ---
---                                          ---
---                                          ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : August 1999         ---
------------------------------------------------
------------------------------------------------




 --- Input basename of the catchment               : ../data/donga

 --- Do you want to read the coordinates from file Coordinates.list?
     (y = yes, n = no)                             : y

     Results on screen (0) or in file  (1)         : 1

     Name of the output file                       : donga_d_outlets.out

 --- Open files   :
     + ../data/donga_ARiver_MonoD.map
     + Coordinates.list

 --- Create file  :
     + Outlets.list
     + donga_d_outlets.out

 --- Read Topography Map
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :     584435328.00
     + Reading ...                                Done

 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 6.9: Sample screen for Outlet_Coordinates program for the Donga subcatchment

6.7 Distances Program for the Donga subcatchment

```
$ ./distances.exe


------------------------------------------------
------------------------------------------------
---                                          ---
---  D i s t a n c e s                       ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : February 2001       ---
------------------------------------------------
------------------------------------------------


 --- Input basename of the catchment               : ../data/donga

 --- Open files :
     + ../data/donga_FilledDTM.map
     + ../data/donga_River_MonoD.map

 --- Create files :
     + ../data/donga_Hillslope_Distance.map
     + ../data/donga_River_Distance.map

 --- Read Topography Map
     + Abscissa bottom-left pixel    :         1.5683304
     + Ordinate bottom-left pixel    :         9.6549732
     + Nb Abscissa                   :               480
     + Nb Ordinates                  :               289
     + Outside value                 :             -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :            327.65
     + Maximal value                 :            499.00
     + Reading ...                                  Done

 --- Read River Map
     + Abscissa bottom-left pixel    :         1.5683304
     + Ordinate bottom-left pixel    :         9.6549732
     + Nb Abscissa                   :               480
     + Nb Ordinates                  :               289
     + Outside value                 :             -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :              0.00
     + Maximal value                 :              3.00
     + Reading ...                                  Done

 --- Calculate Hillslope and River Distances Done

 --- Write Hillslope Distance Map
     + Writing ...                                  Done


 --- Write River Distance Map
     + Writing ...                                  Done


 >-----------------------------------<<<
 >                                   <<<
 > Program successfully terminated.  <<<
 >                                   <<<
 >-----------------------------------<<<
```

Figure 6.10: Sample screen for Distances program for the Donga subcatchment

6.8 Geomorpho Program for the Donga subcatchment

```
$ ./geomorpho.exe


------------------------------------------------------
------------------------------------------------------
---                                                ---
---  G e o m o r p h o                             ---
---                                                ---
---                                                ---
------------------------------------------------------
---  Last Modification : July 2009                 ---
---  Creation          : February 2001             ---
------------------------------------------------------
------------------------------------------------------


 --- Input basename of the catchment               : ../data/donga

 --- Open files :
     + ../data/donga_Hillslope_Distance.map
     + ../data/donga_River_Distance.map
     + ../data/donga_ATB_River_MultiD.map
     + ../data/donga_River_MonoD.map

 --- Create files :
     + ../data/donga_GeomorphoFT.vec
     + ../data/donga_GeomorphoISO.vec

 --- Read Hillslope distances Map
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :          1375.65
     + Reading ...                                 Done

 --- Read River Map
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :            45.90
     + Maximal value                 :         66187.06
     + Reading ...                                 Done

 --- Read ATB Map
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :         -9999.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :             5.84
     + Maximal value                 :            16.55
     + Reading ...                                 Done

 --- Read River Network Map
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :             3.00
     + Reading ...                                 Done
```

Figure 6.11: Sample screen for Geomorpho program for the Donga subcatchment (part 1 of 2)

```
--- Input Velocity (m/s) for :
    + River                          : .6
    + Hillslope                      : .06

--- Input Ac Threshold (0 < x < 1)   : .5

--- Input Time Step (s)              : 10

--- Loop on pixels                          Done
    + Nb pixels considered           :      35063
    + Maximum delay (h)              :      34.12
    + Nb pixels river                :       7880
    + Maximum delay (h)              :      30.60

--- Write Time Distribution for Transfer Function

--- Write Time Distribution for Isochrones

>-----------------------------------<<<
>                                   <<<
> Program successfully terminated. <<<
>                                   <<<
>-----------------------------------<<<
```

Figure 6.12: Sample screen for Geomorpho program for the Donga subcatchment (part 2 of 2)

6.9 Input_Mesh Program for the Donga subcatchment

```
$ ./input_mesh.exe

-------------------------------------------------
-------------------------------------------------
---                                           ---
---  I n p u t    M e s h                     ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/donga

 --- Open files :
     + ../data/donga_River_MonoD.vec
     + ../data/donga_ARiver_MonoD.map

 --- Create files :
     + ../data/donga_Mesh0.vec

 --- Read the River Connection file
     + Number of pixels              :          7880
     + Number of abscissa            :           480
     + Number of ordinates           :           289
     + Mesh size (degrees)           :     0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :        327.65
     + Maximal Elevation (m)         :        476.00
     + Reading ...                                Done

 --- Read River Drainage Area Map
     + Abscissa bottom-left pixel    :     1.5683304
     + Ordinate bottom-left pixel    :     9.6549732
     + Nb Abscissa                   :           480
     + Nb Ordinates                  :           289
     + Outside value                 :         -1.00
     + Mesh size (degrees)           :     0.0008333     (   91.80 meters)
     + Minimal value                 :          0.00
     + Maximal value                 :  584435328.00
     + Reading ...                                Done

 --- Build input mesh file                        Done


 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 6.13: Sample screen for Input_Mesh program for the Donga subcatchment

6.10 Define_Mesh Program for the Donga subcatchment

```
$ ./define_mesh.exe


-------------------------------------------------
-------------------------------------------------
---                                           ---
---  D e f i n e    M e s h                   ---
---                                           ---
-------------------------------------------------
---  Last Modification : July 2009            ---
---  Creation          : February 2001        ---
-------------------------------------------------
-------------------------------------------------


 --- Input basename of the catchment               : ../data/donga

 --- Open files :
     + ../data/donga_River_MonoD.vec
     + ../data/donga_Mesh0.vec
     + ../data/donga_FilledDTM.map

 --- Create files :
     + ../data/donga_Mesh.coord

 --- Read the River Connection file
     + Number of pixels              :          7877
     + Number of abscissa            :           480
     + Number of ordinates           :           289
     + Mesh size (degrees)           :     0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :        327.60
     + Maximal Elevation (m)         :        476.00
     + Reading ...                             Done

 --- Read the Input Mesh file                  Done

 --- Read the Input Mesh file
     + Abscissa bottom-left pixel    :     1.5683304
     + Ordinate bottom-left pixel    :     9.6549732
     + Nb Abscissa                   :           480
     + Nb Ordinates                  :           289
     + Outside value                 :         -1.00
     + Mesh size (degrees)           :     0.0008333     (   91.80 meters)
     + Minimal value                 :        327.65
     + Maximal value                 :        499.00
     + Reading ...                             Done

 --- Detect position of Fixed Outlets
     for hydrological modelling ('y' or 'n')?y

 --- Open file ../data/Outlets.list

 --- Calculate river Strahler orders
     + Nombre de confluences:       1440
     + Ordre de Strahler maximum:      5

 --- Nominal area of meshes (km²) : 25

 --- Mesh watershed(1) or geographic area(2) ? 1

       + Revised nominal area (km²) :      25.41

       + Approx number of meshes    :       23
     + Mesh n°   1:   25.54 km²
     + Mesh n°   2:   22.01 km²
     + Mesh n°   3:   23.79 km²
     + Mesh n°   4:   26.02 km²
     + Mesh n°   5:   29.81 km²
     + Mesh n°   6:   23.88 km²
     + Mesh n°   7:   24.21 km²
     + Mesh n°   8:   25.45 km²
     + Mesh n°   9:   25.55 km²
     + Mesh n°  10:   25.97 km²
     + Mesh n°  11:   24.45 km²
```

Figure 6.14: Sample screen for Define_Mesh program for the Donga subcatchment (part 1 of 2)

```
     + Mesh n°  12:   25.02 km²
     + Mesh n°  13:   22.82 km²
     + Mesh n°  14:   27.34 km²
     + Mesh n°  15:   21.06 km²
     + Mesh n°  16:   23.95 km²
     + Mesh n°  17:   25.43 km²
     + Mesh n°  18:   26.45 km²
     + Mesh n°  19:   27.95 km²
     + Mesh n°  20:   23.87 km²
     + Mesh n°  21:   26.15 km²
     + Mesh n°  22:   24.43 km²
     + Mesh n°  23:   24.56 km²
     + Mesh n°  24:    8.71 km²

--- Total area :    584.44 km²

--- rmse criterion on mesh areas:   3.88
--- Mean Bias on mesh areas     :  -4.17 %
--- Max Bias on mesh areas      :  65.71 %


--- Calculate outlets coordinates

--- Write coordinates file

--- Create file ../data/Outlets.list.updated


>>>-----------------------------------<<<
>>>                                   <<<
>>> Program successfully terminated. <<<
>>>                                   <<<
>>>-----------------------------------<<<
```

Figure 6.15: Sample screen for Define_Mesh program for the Donga subcatchment (part 2 of 2)

6.11 Draw_Mesh Program for the Donga subcatchment

```
$ ./draw_mesh.exe

------------------------------------------------
------------------------------------------------
---                                          ---
---  D r a w    M e s h                      ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : February 2001       ---
------------------------------------------------
------------------------------------------------


 --- Input the basename of the catchment    : ../data/donga

 --- Open files :
     + ../data/donga_FilledDTM.map
     + ../data/donga_Sorted_MonoD.vec
     + ../data/donga_Mesh.coord

 --- Create files :
     + ../data/donga_Mesh_Coord.Map

 --- Read Topography Map :
     + Abscissa bottom-left pixel    :        1.5683304
     + Ordinate bottom-left pixel    :        9.6549732
     + Nb Abscissa                   :              480
     + Nb Ordinates                  :              289
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal value                 :           327.65
     + Maximal value                 :           499.00
     + Reading ...                                Done

 --- Read Connection Vector :
     + Number of pixels              :            69351
     + Number of abscissa            :              480
     + Number of ordinates           :              289
     + Mesh size (degrees)           :       0.0008333     (   91.80 meters)
     + Minimal Elevation (m)         :           327.65
     + Maximal Elevation (m)         :           499.00
     + Reading ...                                Done

 --- Read Mesh coordinates file:
     +   23 meshes read

 --- Take into account Fixed Outlets
     for hydrological modelling ('y' or 'n')?y

 --- Open file ../data/Outlets.list.updated

 --- Calculate Mask :
     + Initialize                    :       Done
     + Exploring upslopes pixels     :
        Iteration  600 Nb Sub Pixels    69351 Surface    584.44 km²
     + Initialize                    :       Done

     ...

       Iteration   70 Nb Sub Pixels     1495 Surface      12.60 km²
     + Writing ...                                Done
 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 6.16: Sample screen for Draw_Mesh program for the Donga subcatchment

Chapter 7

Utilities

Utility programs are provided related to the pre-processing programs.

7.1 LookInMap

This program finds the x,y-pixels that have an exact drainage area -or- the x,y-pixels within a range of drainage areas.

7.1.1 User Entries

The following items are entered by the user:

- BASENAME of the catchment, or SUBBASENAME of a subcatchment
- Options:
  - (1) Look for pixel(s) corresponding to an exact drainage area.
    Enter drainage area (m^2)
  - (2) Look for the pixels associated with a range of drainage areas.
    Enter minimum and maximum drainage areas (m^2)
  - (3) Quit.
    Exit
- Specify whether to write results to screen (0) or file (1)
- If write to file, enter 'UserFileName.ext' to write to
- Repeat options until (3) Quit is selected

7.1.2 Input File

The file read by this program is shown in the following figure:

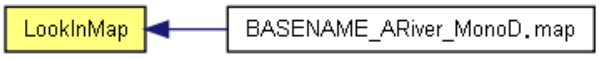

Figure 7.1: File read by LookInMap program

7.1.3 Output File

The file written by this program is shown in the following figure:

Figure 7.2: File written by LookInMap program

If a user specified output file is selected, it will be written to the executable directory unless a path is specified with the file name.

Sample output for the **UserFileName.ext** file for the raw catchment:

```
+ X =        316 Y =        910 Z =   52586024.0000
+ X =        327 Y =       1185 Z =   52501716.0000
+ X =        503 Y =         72 Z =   52543836.0000
+ X =        518 Y =        306 Z =   52569144.0000
+ X =        518 Y =        307 Z =   52560716.0000
+ X =        518 Y =        308 Z =   52535436.0000
+ X =        518 Y =        309 Z =   52518580.0000
+ X =        521 Y =       1079 Z =   52552324.0000
+ X =        535 Y =        623 Z =   52526988.0000
+ X =        536 Y =        624 Z =   52552272.0000
+ X =        536 Y =        625 Z =   52560700.0000
+ X =        537 Y =        626 Z =   52577556.0000
+ X =        603 Y =       1195 Z =   52560732.0000
+ X =        698 Y =        587 Z =   52518556.0000
+ X =        699 Y =        586 Z =   52569120.0000
+ X =        722 Y =        111 Z =   52577532.0000
+ X =        723 Y =        109 Z =   52526964.0000
+ X =        723 Y =        110 Z =   52552248.0000
+ X =        808 Y =        351 Z =   52518544.0000
+ X =        853 Y =       1427 Z =   52510140.0000
+ X =       1071 Y =       1165 Z =   52543864.0000
+ X =       1072 Y =       1164 Z =   52577572.0000
+ X =       1224 Y =        406 Z =   52543848.0000
+ X =       1225 Y =        405 Z =   52518564.0000
+ X =       1248 Y =       1379 Z =   52543828.0000
+ X =       1248 Y =       1380 Z =   52526972.0000
+ X =       1264 Y =         17 Z =   52577556.0000
+ X =       1265 Y =         17 Z =   52543844.0000
+ X =       1444 Y =        101 Z =   52569148.0000
```

7.2 LookInMap_xy

This program finds the drainage areas (m^2) given an x,y-pixel -or- a range of x,y-pixels.

7.2.1 User Entries

The following items are entered by the user:

- BASENAME of the catchment, or SUBBASENAME of a subcatchment
- Options:
  - (1) Look for drainage area for a specified pixel
    Enter pixel x,y-coordinates
  - (2) Look for the drainage areas associated with a range of pixels
    Enter minimum x,y-pixel coordinates (lower left corner of range)
    Enter maximum x,y-pixel coordinates (upper right corner of range
  - (3) Quit
    Exit
- Specify whether to write results to screen (0) or file (1)
- If write to file, enter 'UserFileName.ext' to write to

- Repeat options until (3) Quit is selected

7.2.2 Input File

The file read by this program is shown in the following figure:

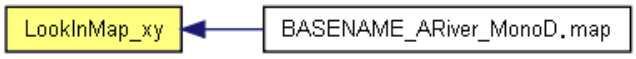

Figure 7.3: File read by LookInMap_xy program

7.2.3 Output File

The file written by this program is shown in the following figure:

Figure 7.4: File written by LookInMap_xy program

Sample output for the **UserFileName.ext** file for the catchment:

```
+ X =        530 Y =        620 Z =              0.0000
+ X =        530 Y =        621 Z =              0.0000
+ X =        530 Y =        622 Z =              0.0000
+ X =        530 Y =        623 Z =              0.0000
+ X =        530 Y =        624 Z =        1230377.1250
+ X =        530 Y =        625 Z =         219108.2344
+ X =        530 Y =        626 Z =              0.0000
+ X =        530 Y =        627 Z =              0.0000
+ X =        530 Y =        628 Z =              0.0000
+ X =        530 Y =        629 Z =              0.0000
+ X =        530 Y =        630 Z =              0.0000
+ X =        531 Y =        620 Z =              0.0000
+ X =        531 Y =        621 Z =              0.0000
+ X =        531 Y =        622 Z =              0.0000
+ X =        531 Y =        623 Z =              0.0000
+ X =        531 Y =        624 Z =        1466339.8750
+ X =        531 Y =        625 Z =              0.0000
+ X =        531 Y =        626 Z =              0.0000
+ X =        531 Y =        627 Z =              0.0000
+ X =        531 Y =        628 Z =              0.0000
+ X =        531 Y =        629 Z =              0.0000
+ X =        531 Y =        630 Z =              0.0000

. . .        . . .          . . .                . . .

+ X =        539 Y =        620 Z =              0.0000
+ X =        539 Y =        621 Z =              0.0000
+ X =        539 Y =        622 Z =              0.0000
+ X =        539 Y =        623 Z =              0.0000
```

```
+ X =        539 Y =        624 Z =              0.0000
+ X =        539 Y =        625 Z =              0.0000
+ X =        539 Y =        626 Z =              0.0000
+ X =        539 Y =        627 Z =              0.0000
+ X =        539 Y =        628 Z =       53100044.0000
+ X =        539 Y =        629 Z =       53116900.0000
+ X =        539 Y =        630 Z =       53125328.0000
+ X =        540 Y =        620 Z =              0.0000
+ X =        540 Y =        621 Z =              0.0000
+ X =        540 Y =        622 Z =              0.0000
+ X =        540 Y =        623 Z =              0.0000
+ X =        540 Y =        624 Z =              0.0000
+ X =        540 Y =        625 Z =              0.0000
+ X =        540 Y =        626 Z =              0.0000
+ X =        540 Y =        627 Z =              0.0000
+ X =        540 Y =        628 Z =              0.0000
+ X =        540 Y =        629 Z =              0.0000
+ X =        540 Y =        630 Z =              0.0000
```

7.3 Example Screens

```
$ ./lookinmap.exe

------------------------------------------------
------------------------------------------------
---                                          ---
---  L o o k   I n   M a p                   ---
---                                          ---
---                                          ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : August 1999         ---
------------------------------------------------
------------------------------------------------

--- Input basename of the catchment : ../data/ohhvo

--- Open files :
    + ../data/ohhvo_ARiver_MonoD.map

--- Read Map File :
    + Abscissa bottom-left pixel    :        1.4866670
    + Ordinate bottom-left pixel    :        8.9766670
    + Nb Abscissa                   :             1582
    + Nb Ordinates                  :             1459
    + Outside value                 :            -1.00
    + Mesh size (degrees)           :        0.0008333     (   91.80 meters)
    + Minimal value                 :             0.00
    + Maximal value                 :   14354648064.00
    + Reading ...                                Done

--- Do you wish to :
    + Look for an exact value   (1)
    + Look for a range of value (2)
    + Quit                      (3) : 1

    + Value                         : 52577556
    + On screen (0) or in file  (1) : 0

--- Search in progress ...
    + X =        537 Y =        626 Z =   52577556.0000
    + X =       1264 Y =         17 Z =   52577556.0000

--- Do you wish to :
    + Look for an exact value   (1)
    + Look for a range of value (2)
    + Quit                      (3) : 2

    + Min and Max values            : 52500000,52600000
    + On screen (0) or in file  (1) : 1
    + Name of the output file       : lookinmap.out

--- Search in progress ...

--- Do you wish to :
    + Look for an exact value   (1)
    + Look for a range of value (2)
    + Quit                      (3) : 3

>>>-----------------------------------<<<
>>>                                   <<<
>>> Program successfully terminated. <<<
>>>                                   <<<
>>>-----------------------------------<<<
```

Figure 7.5: Sample screen for LookInMap program for the raw catchment

```
$ ./lookinmap_xy.exe


------------------------------------------------
------------------------------------------------
---                                          ---
---  L o o k   I n   M a p _ x y             ---
---                                          ---
---                                          ---
---                                          ---
------------------------------------------------
---  Last Modification : July 2009           ---
---  Creation          : August 1999         ---
------------------------------------------------
------------------------------------------------


 --- Input basename of the catchment : ../data/ohhvo

 --- Open files :
     + ../data/ohhvo_ARiver_MonoD.map

 --- Read Map File :
     + Abscissa bottom-left pixel    :        1.4866670
     + Ordinate bottom-left pixel    :        8.9766670
     + Nb Abscissa                   :             1582
     + Nb Ordinates                  :             1459
     + Outside value                 :            -1.00
     + Mesh size (degrees)           :        0.0008333      (   91.80 meters)
     + Minimal value                 :             0.00
     + Maximal value                 :   14354648064.00
     + Reading ...                                Done

 --- Do you wish to :
     + Look for an exact pixel   (1)
     + Look for a range of pixels(2)
     + Quit                      (3) : 1

     + X, Y-coordinates for pixel    : 537,626
     + On screen (0) or in file  (1) : 0

 --- Search in progress ...
     + X =        537 Y =        626 Z =        52577556.0000

 --- Do you wish to :
     + Look for an exact pixel   (1)
     + Look for a range of pixels(2)
     + Quit                      (3) : 2

     + Min X, Y-pixel                : 530,620

     + Max X, Y-pixel                : 540,630
     + On screen (0) or in file  (1) : 1
     + Name of the output file       : lookinmap_xy.out

 --- Search in progress ...

 --- Do you wish to :
     + Look for an exact pixel   (1)
     + Look for a range of pixels(2)
     + Quit                      (3) : 3

 >>>-----------------------------------<<<
 >>>                                   <<<
 >>> Program successfully terminated. <<<
 >>>                                   <<<
 >>>-----------------------------------<<<
```

Figure 7.6: Sample screen for LookInMap_xy program for the raw catchment